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אני, (שם המבקש, מענו - ולגבי גוף מאוגד - מקום התאגדותו)  
I (Name and address of applicant, and, in case of a body corporate, place of incorporation)

SuperSeal Ltd.  
8 HaSadot Street  
46 910 Kfar Shmaryahu

סופרסיל בע"מ  
השדות 8  
כפר שמריהו 46910

Inventor/s: Zeev BIRGER

הממציא/ים: זאב בירגר

שמה הוא:  
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of an invention, the title of which is:

אגרגטים הדורפוביים ושימושים בהם

(בעברית)  
(Hebrew)

HYDROPHOBIC AGGREGATE AND APPLICATIONS THEREOF

(באנגלית)  
(English)

hereby apply for a patent to be granted to me in respect thereof.

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*בקשת חלוקה- Application for Division		*בקשת פטנט מוסף- Application for Patent of Addition		*דרישת דין קדימה Priority Claim	
מבקשת פטנט from Application		*לבקשה/לפטנט for Patent/Apl.		מספר/סימן Number/Mark	תאריך Date
No. _____ dated _____		No. _____ dated _____		60/486,419 60/486,420	14 July 2003 14 July 2003
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For the Applicant  
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**אגרגטים הדרופוביים ושימושים בהם**

**HYDROPHOBIC AGGREGATE AND APPLICATIONS THEREOF**

## HYDROPHOBIC AGGREGATE AND APPLICATIONS THEREOF

The teachings of U.S. Provisional Patent Application Nos. 60/486,419 and 60/486,420, both filed on July 14, 2003, are incorporated herein by reference.

### FIELD AND BACKGROUND OF THE INVENTION

The present invention relates to novel uses of hydrophobic aggregate in waterproofing applications.

In many applications it is desired to prevent moisture from reaching critical regions using hydrophobic materials which repel water. In the area of civil engineering, when water percolate into construction, salts and minerals present in the water damage the concrete (or other materials from which the construction is made); and causes corrosion and deformation to its reinforcing steel bars or wire fabric. Such corrosion and deformation leads to the appearance of cracks in the concrete and, eventually, to a local reduction of construction strength. Other internal objects, such as pipes, electrical wires, communication channels and the like may also be damage by moisture.

The presence of water in the house is associated with numerous of unpleasant evidences such as, moisture at the base of the walls, under carpeting or under floor tiles; rust at the base of steel posts; stains, discoloration or decay of wood, paneling, drywall and other objects close to the floor, walls or ceiling; molds and mildew on concrete, furnishings or carpets; efflorescence ("white powder") on the concrete; peeled floor tiles; damp odor; "sweating" walls (condensation of excessive humidity); condensation of water on windows; plugged or damaged rain gutters; growth of moss and the like.

Moisture may percolate into the construction, either vertically, for example because of accumulation of water on roofs or floors of construction/foundations, or horizontally, by leakage of water through external walls of a building for example, because of extreme weather conditions. A sever problem of horizontal leakage is in buried walls or portions thereof, where hydrostatic pressure generated by excess moisture in the surrounding soil pushing in on the outside of the foundation wall, significantly contributes to horizontal leakage.

The percolation of moisture through concrete walls is explained by the porosity of the concrete (about 12 % - 20 %), formed during the curing process when surplus

water creates a network of interconnected capillaries, about 10-100 nm in diameter. These capillaries contribute to the percolation of moisture there through via capillary forces. As the concrete ages, the water percolation, gradually leaches out the concrete and makes it more and more porous.

5 Another problem caused by moisture is mildew, which, apart from being unaesthetic, creates a musty odor. Even though a substantial amount of standing water may be removed by prior art waterproofing methods that utilize a drainage conduit, residual moisture will still cause mildew problems. It is recognized that a prolonged exposure to mildew may cause many health problems, such as, allergies, asthma, skin  
10 diseases and the like.

Basement is by far the largest source of moisture in a house. Covered floor and walls in the finished basement trap moisture and eventually cause damp or wet basement. As the pH level of the concrete is high, the alkalis present in the concrete dissolved by the water and attack paints and floor tiles. Hence, even if the basement  
15 looks dry, moisture is pouring in by seeping through capillaries. The mildew, which is typically initiated in the basement due to its excessive amount of moisture, may spread to other areas of the house above ground, e.g., by ventilation.

In many countries sand is used as a bed under the floor tiles and is recommended by standards in order to reduce noise. Water, originating from periodic  
20 cleaning plumbing leakage or heavy rain (e.g., in tiled roofs) generate a substantial amount of excessive weight, up to approximately 100 Kilograms of water per square meter. Large portion of the water is trapped under the tiles and the sand thus remains wet for many years. Such excessive weight is typically taken under consideration by the engineer in the planning stages of the building, which, in order to increase the  
25 strength to the construction, uses more concrete and reinforcing material under the sand bed. The contribution of the water and construction extra strengthening to the overall weight accelerates the sinking of the building. The problem is only aggravated in hanging structures such as balconies and overpasses, interconnecting different parts of buildings.

30 In addition to its excessive weight, the wet sand under the tiles attracts insects, such as ants, warms, aphids, dust mites and the like. Apart from the recognised health problems associated with such attraction, the insects excavate through the sand and accelerate sinking of the tiles.

Being wet most of the time, the sand under the floor tiles becomes a thermal conductor, thus reducing any isolation pretended to be achieved in the design stages of the building. In some buildings, an electrical heating system is constructed under the floor. The contact between these systems and the wet sand may cause a severe damage to the system, or, in extreme cases, even fire may occur.

With respect to under floor waterproofing of balconies or tiled roofs, all prior art methods are directed at positioning a waterproofing material such as a sealing sheet, a bituminous membrane or a solvent based elastomeric coat, under the bed sand supporting the floor tiles. However, almost irrespectively of their quality, the life time of these waterproofing materials is not sufficient, because of the salts containing moisture being present in the sand.

Even in constructions or part of constructions where sand is not in contact with the waterproofing material, the life time of prior art materials is limited. Alkalis dissolved in the water attack paints and adhesives and damage the waterproofing material, by formation of cracks, peels or blisters.

An additional indoors problem related to sealing means is the problem of elevated levels of Radon gas which may be found in houses, typically, but not exclusively, in the lower parts thereof, *e.g.*, basements. Radon is an invisible and odourless radioactive gas, produced by the decay of radioactive heavy metals uranium and thorium, dispersed throughout the Earth's crust. The by-products of the radioactive decay of these metals are lighter radioactive heavy metals which also decay into lighter metals and so on. The decay chain continuously produces radium, which decays into radon isotopes, mainly Radon-222 and Radon-220 (the latter also known as Thoron), where the Radon-222 isotope is the most common indoors radioactive gas.

Radon decay products are tiny radioactive solid particles which float in the air and, breathed by human, get trapped in the lungs, trachea and bronchi. Because of these decay products, the Radon, at the levels common in homes, is about 1,000 times more lethal than the safety limits on any other toxin or carcinogen.

Being the heaviest known gas (nine times heavier than air), the Radon gas naturally moves into the permeable soil and the gravel bed surrounding the foundations of the house and subsequently diffusively penetrates into the house through the above mentioned openings and pores in concrete. Radon is soluble in

water and therefore carried to the vicinity of the house by underground streams, and further into the house by the percolation of water, *e.g.*, through the concrete. The most common carrier of Radon into the house is water.

Moisture and water also cause damage to buried objects, such as underground pipes, storage tanks (*e.g.*, gas tanks) and tunnels. Due to moisture, corrosion caused by electrolysis, digesting materials, insects and/or micro organisms present in the sand, many buried objects are exposed to damaging processes which reduce the lifetime of the objects. In cases where the buried object contains hazardous materials any leakage there from may have a severe environmental consequences.

The combination of moisture and sand tends to harden or freeze. The formed hard material is known to transform axial stresses from the surrounding environment to the buried object. When the level of the axial stresses exceeds the object's characteristic strength, the object is damaged. To prevent the above axial stresses, the objects are made stronger and/or being buried deep into the ground. It is recognized, however, that the cost of positioning objects underground increases with the depth in which these objects are to be buried. Moreover, deep buried objects are difficult to be accessed, *e.g.*, for maintenance or replacement.

One way to protect buried objects is by applying a sealing coat on the objects so as to prevent the above materials or corrosion from damaging the objects. However, although in general these coats survive the attack of the digesting materials or organisms, very often local damages to the coat are inevitable (for example due to axial stresses), which local damages are sufficient to initiate the erosion of the object.

Buried pipes and electrical or communication channels are often positioned inside hollow underground tubes. The hollow tubes also ease access to the buried object, for maintenance purposes. However, water or other liquids occasionally find the way into the space between the buried object and the internal surface of the surrounding tube (*e.g.*, through holes or cracks formed in the external surfaces of the tubes, or through the gap between contacting tubes). The water flows through the tube and causes damages to the buried objects or to connection boxes at the end of the tube.

Another structure for which waterproofing is required is a water reservoir, where the base and the walls thereof need to be impermeable so as to prevent water from leaking out. The problem of leaking reservoir is crucial in arid regions where one desire to maintain the content of the reservoir for as much as time possible.

A typical reservoir is a flat area surrounded by a sloping embankment. In all prior art waterproofing methods, the bottom of the reservoir (both the flat base and the sloping embankment) are covered with sealing sheets (typically made of high density polyethylene, HDPE), adhered or welded to each other. This method suffers from many drawbacks. First, because the waterproofing is by a plurality of bonded sealing sheets, there are many areas near the connection between two adjacent sheets where the bonding is damaged or not perfect, and the sheets become permeable. Second, due to its limited elasticity, the sealing sheet tends to be damaged by hard objects, being in contact therewith either from above or from below. Third, during maintenance, when the bottom of the reservoir is cleaned by light machinery or manually, the sealing sheets may be ruptured. Fourth, forces induces earth movements or cracks formation (e.g., in a man made concrete reservoir) rupture the sealing sheets. An additional limitation of prior art method is originated by colonies of insects and organisms present under the sealing sheets. In which case purification chemicals are required to purify the content of the reservoir.

Design considerations for hydrophobic materials to be used for waterproofing any of the above structures include water intrusion pressure, thickness, chemical compatibility, airflow, temperature compatibility and the like. Water intrusion pressure is a measure of a critical pressure under which water are forced through the hydrophobic material. Chemical compatibility is important in applications where the hydrophobic material comes in contact with corrosive material.

Over the years, numerous hydrophobic materials have been developed, including PTFE, nylon, glass fibers, polyethersulfone and aggregates having hydrophobic properties.

A water-repellent composite materials material is disclosed in U.S. Patent No. 3,562,153, to Tully *et al.* The oil absorbent compositions of the Tully *et al.* patent are obtained by treating a liquid absorbent material, which may optionally be particulate in nature, with a colloidal metal or metalloid oxide which is chemically bonded to an organosilicon compound to render the metal or metalloid oxide hydrophobic. The hydrophobic oxide-treated absorbent composition is contacted with the oil-contaminated water and selectively removes the oil there from. The oil absorbent composition of Tully *et al.* is reported to have excellent water repellency, thus enabling it to maintain its oil absorbent efficiency for long immersion periods.



U.S. Patent No. 4,474,852, to Craig, which is incorporated by reference as if fully set forth herein, combines ideas of several prior art patents (US Patent Nos. 3,567,492, 3,672,945, 3,973,510, 3,980,566, 4,148,941 and 4,256,501, the contents of all of which are hereby incorporated by reference). According to Craig, hydrophobic composites having superior water repellency are obtainable by depositing on a particulate and granular core material an adherent first coat which comprises a film-forming polyurethane and asphalt, as an optional additive, and applying to the thus coated core material a second coat comprising a hydrophobic colloidal oxide such as, for example, hydrophobic fumed silica. According to the teachings of Craig, the adherent first coat should not exceed 1 weight percentage of the total dry aggregate weight, while the second coat is between 0.025 and 0.25 weight percentage of this total weight. Further according to the teachings of Craig, hydrophobic composites prepared in this manner not only prevent water from adhering to the surfaces of the individual composite particles, but also from entering the interstitial spaces of the aggregates of the composites.

WO 03/044124 to Forgacs, which is also incorporated by reference as if fully set forth herein, also discloses a method of preparing hydrophobic aggregate, which is based on the teachings of Craig (U.S. Patent No. 4,474,852 above). According to the teachings of WO 03/044124, the hydrophobic aggregate disclosed in U.S. Patent No. 4,474,852 are not satisfactory as they do not withstand water pressure higher than 2-3 centimeters.

In a search for a method of producing hydrophobic aggregate with improved water-repellency and oil absorbency performance and improved durability under higher water pressures, it was concluded, according to the teachings of WO 03/044124, that an improved method of preparing hydrophobic aggregate, as compared with the teachings of Craig, should include changes relating to the compositions of the first and second coat and the relative amounts thereof, to the temperature in the various process steps and to the mixing rate during the course of preparation.

Hence, the method disclosed in WO 03/044124 includes depositing on a particulate or granulate core material an adherent first coat which comprises a film-forming agent such as polyurethane and optionally a gluing agent such as liquid asphalt, and applying to the thus coated core material a second coat which comprises a

hydrophobic fumed silicate or any other superhydrophobic powder. According to the teachings of WO 03/044124, the adherent first coat constitutes about 1-2 weight percentages of the total dry aggregate weight while the second coat constitutes more than 5 weight percentages of this total weight. Further according to the teachings of WO 03/044124, such hydrophobic aggregate are capable of holding a water pressure of up to 20-30 cm.

Although WO 03/044124 teaches the use of superhydrophobic powders other than hydrophobic fumed silica, this reference neither specifies nor exemplifies such a superhydrophobic powder. This reference also fails to demonstrate any performance of the hydrophobic aggregate disclosed therein with regard to both, water repellency and its behavior under high water pressures. Furthermore, it is well known in the art that using such a large amount of hydrophobic fumed silica as the second coat, as taught by WO 03/044124, reduces the cost-effectiveness as well as the simplicity of the process.

In addition, as hydrophobic fumed silica, as well as other metal oxides treated with organosilicon compounds, such as those disclosed in the Craig patent, are characterized as acidic substances, aggregates coated by such materials are susceptible to reactions with alkaline reagents such as detergents. This feature limits the use of such aggregates in applications where detergents may be in contact with the hydrophobic aggregate, such as, for example, periodic cleaning of floors in a house.

US Patent 4,474,852 mentioned hereinabove describes several applications for its hydrophobic composites in waterproofing applications. Mainly as a top coat on paved surfaces, such as asphalt or concrete, a flood coat of asphalt sealer should first be applied over the surface, immediately after which a heavy coat of the hydrophobic composites may be sprayed over and rolled into the asphalt sealer, providing a watertight top coat. The same top coating technique may be used in pothole repairs in roadways.

The composites may also be used as a substitute for common aggregate in asphalt roofing or shingles, or in built-up roofing. In such applications, the hydrophobic composites are effective in preventing water penetration and resulting damage caused by freeze-thaw cycles as well as dimensional changes due to wetting and drying. US Patent 4,474,852 also claims utility as a top coat on paved surfaces, such as asphalt or concrete road surfaces or bridge decking, providing a water-tight

finish, which substantially reduces freeze-thaw damage, and which is unaffected by salt compositions normally used for ice removal. In addition, these hydrophobic composites may be applied to painted surfaces to provide a durable, waterproof finish over wood, metal, concrete, stone, brick and certain synthetic substrates. Such hydrophobic composites may also be blended with suitable binding agents to provide a water-repellent coat.

As the American Concrete Institute (ACI) recommends a 3-inch pervious sand bed spread on top of waterproofing sheet under the building, the hydrophobic composite of US Patent 4,474,852 may also be used as a waterproofing agent in pavement construction, as a fill or bed material under concrete slabs or as a gravel fill or ballast for road beds or sidewalks. However, as will be appreciated by a skilled artisan, free-flowing aggregate are made of extremely small particulates hence being easily carried in the wind and washed out by running water. Therefore, without specific and enabling instructions, it would be very difficult and probably not practical to use the hydrophobic aggregate in its flowing form.

There is thus a widely recognized need for, and it would be highly advantageous to have hydrophobic aggregate and applications thereof devoid of the above limitations.

## SUMMARY OF THE INVENTION

According to one aspect of the present invention there is provided a free-flowing hydrophobic aggregate capable of repelling a predetermined maximal pressure of liquid, the free-flowing hydrophobic aggregate comprising a plurality of differently sized particulates, wherein at least one of a size distribution of the particulates, a contact angle between the liquid and the particulates and a characteristic distance between adjacent particulates is selected so that when a layer of the free-flowing hydrophobic aggregate is in contact with a liquid having a pressure lower than or equal to the predetermined maximal pressure, percolation of the liquid through the free-flowing hydrophobic aggregate is prevented.

According to further features in preferred embodiments of the invention described below, the liquid is water.

According to still further features in the described preferred embodiments the layer has a thickness from about 1 cm to about 10 cm and the predetermined maximal pressure is equivalent to a column of water having a height above 30 cm.

5 According to still further features in the described preferred embodiments the layer has a thickness from about 1 cm to about 10 cm and further wherein the predetermined maximal pressure is equivalent to a column of water having a height above 100 cm.

10 According to still further features in the described preferred embodiments the size distribution is characterized by a variance ranging from 1 micrometer to 1400 micrometer.

According to still further features in the described preferred embodiments the size distribution is selected so that a maximal diameter of capillaries formed between the particulates is suitable for repealing the predetermined maximal pressure of the liquid.

15 According to still further features in the described preferred embodiments the size distribution is selected so that a maximal diameter of capillaries formed between the particulates is from 1 nanometer to 500 nanometers.

20 According to still further features in the described preferred embodiments the free-flowing hydrophobic aggregate further comprising inflatable particulates size wise compatible with capillaries formed between the particulates and capable of absorbing the fluid.

According to still further features in the described preferred embodiments a diameter of the inflatable particulates is from about 1 micrometer to about 1000 micrometers.

25 According to still further features in the described preferred embodiments the hydrophobic powder comprises inflatable particulates capable of absorbing the fluid.

According to still further features in the described preferred embodiments a diameter of the inflatable particulates is from about 1 micrometer to about 100 micrometers.

30 According to still further features in the described preferred embodiments an absorption capability of the inflatable particulates is from about 100 to about 5000 by weight.

According to still further features in the described preferred embodiments a freezing temperature of the inflatable particulates is below about -20 degrees centigrade, both in an inflated state and in a deflated state of the inflatable particulates.

5 According to still further features in the described preferred embodiments the inflatable particulates, when in a deflated state, constitute less than 2 percent of the free-flowing hydrophobic aggregate by volume.

According to still further features in the described preferred embodiments the inflatable particulates comprise a super absorbent polymer.

10 According to still further features in the described preferred embodiments the inflatable particulates comprises sodium being cross linked with polyacrylic acid.

According to still further features in the described preferred embodiments the inflatable particulates comprises anticracking agent.

15 According to another aspect of the present invention there is provided a hydrophobic brick comprising a protective encapsulation having a predetermined shape, and a free-flowing hydrophobic aggregate being encapsulated in the protective encapsulation.

20 According to yet another aspect of the present invention there is provided a method of waterproofing a portion of a structure being in contact with a ground, comprising: providing a bed of a free-flowing hydrophobic aggregate; and positioning the structure over or in the bed of the free-flowing hydrophobic aggregate.

According to still further features in the described preferred embodiments the method further comprising protecting the bed of free-flowing hydrophobic aggregate by enclosing the bed in a protective structure.

25 According to still further features in the described preferred embodiments a thickness of the bed of free-flowing hydrophobic aggregate is between 1 and 15 cm.

According to still further features in the described preferred embodiments a thickness of the bed of free-flowing hydrophobic aggregate is between 4 and 10 cm.

30 According to still another aspect of the present invention there is provided a method of waterproofing an underground wall of a structure, comprising providing at least one sidewall of a free-flowing hydrophobic aggregate adjacent to the underground wall of the structure.

According to further features in preferred embodiments of the invention described below, the method further comprising protecting the sidewall of free-flowing hydrophobic aggregate by enclosing the sidewall in a protective structure.

5 According to still further features in the described preferred embodiments the method further comprising refilling the sidewall of free-flowing hydrophobic aggregate, if needed with time.

10 According to still further features in the described preferred embodiments the sidewall of the free-flowing hydrophobic aggregate comprises an arrangement of hydrophobic bricks, each being a protective encapsulation having a predetermined shape and encapsulating the free-flowing hydrophobic aggregate.

According to still further features in the described preferred embodiments the method further comprising coating the underground wall of the structure with a waterproofing substance selected from the group consisting of a liquid and a paste.

15 According to still further features in the described preferred embodiments the structure is an existing structure, and the method is applied as a repair method.

According to still further features in the described preferred embodiments the structure is a new structure, and the method is applied during construction.

20 According to an additional aspect of the present invention there is provided a method of waterproofing a floor of a structure, comprising providing a bed of a free-flowing hydrophobic aggregate onto the structure and positioning the floor of the structure over the bed of the free-flowing hydrophobic aggregate.

According to further features in preferred embodiments of the invention described below, the method further comprising protecting the bed of the free-flowing hydrophobic aggregate by enclosing the bed in a protective structure.

25 According to still further features in the described preferred embodiments the method further comprising embedding a water pipe in the bed of the free-flowing hydrophobic aggregate.

30 According to yet an additional aspect of the present invention there is provided a method of waterproofing a roof of a structure, the roof having sidewalls, the method comprising: applying a bed of a free-flowing hydrophobic aggregate on the roof; and covering the bed of the free-flowing hydrophobic aggregate, to protect the bed.

According to further features in preferred embodiments of the invention described below, the covering comprises applying a floor over the bed of the free-flowing hydrophobic aggregate.

5 According to still further features in the described preferred embodiments the bed of the free-flowing hydrophobic aggregate comprises an arrangement of hydrophobic bricks, each being a protective encapsulation having a predetermined shape and encapsulating the free-flowing hydrophobic aggregate.

10 According to still further features in the described preferred embodiments a thickness of the bed of the free-flowing hydrophobic aggregate is between 1 and 15 cm.

According to still further features in the described preferred embodiments a thickness of the bed of the free-flowing hydrophobic aggregate is between 4 and 7 cm.

15 According to still an additional aspect of the present invention there is provided a method of waterproofing a reservoir, the method comprising: placing a flooring bed of a free-flowing hydrophobic aggregate over a base of the reservoir; and placing walls of the free-flowing hydrophobic aggregate over walls of the reservoir; wherein at least one of the flooring bed and the walls of the free-flowing hydrophobic aggregate are covered by a protective structure designed and constructed to maintain the free-flowing hydrophobic aggregate in place.

20 According to further features in preferred embodiments of the invention described below, a thickness of the flooring bed of free-flowing hydrophobic aggregate is between 4 and 15 cm.

25 According to still further features in the described preferred embodiments the method further comprising mixing the free-flowing hydrophobic aggregate with lightweight aggregates.

According to still further features in the described preferred embodiments the protective structure is selected from the group consisting of tiles, geotechnic fabric, concrete, plastic and combination thereof.

30 According to still further features in the described preferred embodiments at least one of the flooring bed and the sidewalls of the free-flowing hydrophobic aggregate comprises an arrangement of hydrophobic bricks, each being a protective encapsulation having a predetermined shape and encapsulating the free-flowing hydrophobic aggregate.

According to still further features in the described preferred embodiments the protective encapsulation is made from a degradable material.

According to a further aspect of the present invention there is provided a method of protecting an object buried underground, the method comprising providing  
5 a free-flowing hydrophobic aggregate and surrounding the object by a layer of the free-flowing hydrophobic aggregate in a manner that the layer of the free-flowing hydrophobic aggregate is interposed between the object and the ground.

According to further features in preferred embodiments of the invention described below, the size distribution is selected so that the free-flowing hydrophobic  
10 aggregate is characterized by a minimal water absorption capability.

According to still further features in the described preferred embodiments the predetermined thermal properties are selected from the group consisting of thermal conductivity, specific heat capacity and latent heat.

According to still further features in the described preferred embodiments the  
15 size distribution is selected so that the free-flowing hydrophobic aggregate is capable of allowing evaporation of the liquid.

According to still further features in the described preferred embodiments the size distribution is proportional to the predetermined maximal pressure.

According to still further features in the described preferred embodiments a  
20 cosine of the contact angle is proportional to the predetermined maximal pressure, the contact angle is measured from a tangent to a surface defined by the free-flowing hydrophobic aggregate.

According to still further features in the described preferred embodiments the characteristic distance is inversely proportional to the predetermined maximal  
25 pressure.

According to still further features in the described preferred embodiments the size distribution is selected so that the free-flowing hydrophobic aggregate is characterized by a predetermined specific weight.

According to still further features in the described preferred embodiments the  
30 size distribution is selected so that the free-flowing hydrophobic aggregate is characterized by predetermined thermal properties.



According to still further features in the described preferred embodiments the size distribution is selected so that the free-flowing hydrophobic aggregate is characterized by predetermined acoustical isolation ability.

5 According to still further features in the described preferred embodiments the size distribution is selected so that the free-flowing hydrophobic aggregate is capable of allowing evaporation of liquid.

According to still further features in the described preferred embodiments the plurality of differently sized particulates comprises a particulated core material coated by a hydrophobic powder selected so as to provide the contact angle.

10 According to still further features in the described preferred embodiments the hydrophobic powder comprises at least one impure element having a hydrocarbon chain attached thereto.

According to still further features in the described preferred embodiments the hydrocarbon chain is covalently attached to the at least one impure element.

15 According to still further features in the described preferred embodiments the hydrocarbon is a residue of a fatty acid.

According to still further features in the described preferred embodiments the hydrophobic powder is bonded to the particulated core material via an adherent layer.

20 According to still further features in the described preferred embodiments the particulated core material is selected from the group consisting of sand, gravel, slag, porcelanit, dolomite, porcelain, basalt, quartz sand, coal ash, chalk, zeolite, montmorillonite, agapultite, flint, bentonite, perlite, mica, wood chips, nut shells, sawdust and combinations thereof.

25 According to still further features in the described preferred embodiments the adherent layer comprises a film-forming agent.

According to still further features in the described preferred embodiments the adherent layer further comprises a gluing agent.

According to still further features in the described preferred embodiments the hydrophobic powder further comprises hydrophobic fumed silica.

30 According to still further features in the described preferred embodiments the free-flowing hydrophobic aggregate further comprises at least one additive selected from the group consisting of a coloring agent, a UV resistant agent, a bleaching agent and an abrasive agent.

The present invention successfully addresses the shortcomings of the presently known configurations by providing methods of waterproofing structures with hydrophobic aggregate. Specifically, the present invention relates to using free-flowing hydrophobic aggregate in a variety of waterproofing applications, while providing protection to the flowing aggregates from wind and water erosion.

Unless otherwise defined, all technical and scientific terms used herein have the same meaning as commonly understood by one of ordinary skill in the art to which this invention belongs. Although methods and materials similar or equivalent to those described herein can be used in the practice or testing of the present invention, suitable methods and materials are described below. In case of conflict, the patent specification, including definitions, will control. In addition, the materials, methods, and examples are illustrative only and not intended to be limiting.

#### **BRIEF DESCRIPTION OF THE DRAWINGS**

The invention is herein described, by way of example only, with reference to the accompanying drawings. With specific reference now to the drawings in detail, it is stressed that the particulars shown are by way of example and for purposes of illustrative discussion of the preferred embodiments of the present invention only, and are presented in the cause of providing what is believed to be the most useful and readily understood description of the principles and conceptual aspects of the invention. In this regard, no attempt is made to show structural details of the invention in more detail than is necessary for a fundamental understanding of the invention, the description taken with the drawings making apparent to those skilled in the art how the several forms of the invention may be embodied in practice.

In the drawings:

FIG. 1 schematically illustrates a free-flowing hydrophobic aggregate, having a plurality of differently sized particulates, in accordance with a preferred embodiment of the present invention;

FIGs. 2A-B schematically illustrate prior-art methods of waterproofing a foundation of a house;

FIGs. 3A-C schematically illustrate methods of waterproofing a foundation of a house, in accordance with a preferred embodiment of the present invention;

FIGs. 4A-B schematically illustrate a hydrophobic brick and a hydrophobic brick wall, in accordance with a preferred embodiment of the present invention;

5 FIGs. 5A-B schematically illustrate methods of waterproofing a floor of a house, in accordance with a preferred embodiment of the present invention;

FIGs. 6A-B schematically illustrate prior-art methods of waterproofing a roof;

FIG. 7 schematically illustrates a method of waterproofing a flat roof, in accordance with a preferred embodiment of the present invention;

10 FIG. 8 schematically illustrates a method of waterproofing a reservoir, in accordance with a preferred embodiment of the present invention;

FIG. 9 schematically illustrates tiles with toothed edges, used for holding hydrophobic aggregate in place, in accordance with a preferred embodiment of the present invention; and

15 FIG. 10 schematically illustrates a method of protecting an object buried underground, in accordance with a preferred embodiment of the present invention.

#### **DESCRIPTION OF PREFERRED EMBODIMENTS**

20 The present invention is of novel uses of hydrophobic aggregates in waterproofing applications. Specifically, the present invention relates to the use of free-flowing hydrophobic aggregates in a variety of waterproofing applications, while providing for protection to the free-flowing aggregates from wind and water erosion. The present invention is further of a free-flowing hydrophobic aggregate and of a hydrophobic brick capable of withstanding a wide range of water pressures.

25 The principles and operation of the present invention may be better understood with reference to the drawings and accompanying descriptions.

Before explaining at least one embodiment of the invention in detail, it is to be understood that the invention is not limited in its application to the details of construction and the arrangement of the components set forth in the following  
30 description or illustrated in the drawings. The invention is capable of other embodiments or of being practiced or carried out in various ways. Also, it is to be understood that the phraseology and terminology employed herein is for the purpose of description and should not be regarded as limiting.

According to one aspect of the present invention there is provided a free-flowing hydrophobic aggregate, referred to herein as aggregate 1, having enhanced waterproofing properties. Aggregate 1 is capable of repealing a predetermined maximal pressure of liquid. As further detailed herein under, by judiciously selecting  
5 several parameters of aggregate 1, a layer of the aggregate of relatively small thickness (of the order of centimeters) is sufficient to withstand a column of water or any other liquid of interest. According to a preferred embodiment of the present invention, the column is above 30 cm in height, more preferably above 100 cm in height, most preferably above 10 m in height. A typical thickness of the layer is from about 1 cm  
10 to about 20 cm.

As used herein, the term about shall mean  $\pm 10\%$ .

The ability of any hydrophobic material to repeal water basically depends on the surface tension of the liquid being in contact with the hydrophobic material. In any liquid, the cohesive forces between molecules present deep in the liquid are shared  
15 with all neighboring atoms. The surface molecules of the liquid have no neighboring atoms of the same type above and exhibit stronger cohesive forces upon the molecules directly associated with them on the surface. From a macroscopic point of view, the enhanced intermolecular interaction at the surface of the liquid is observed as the surface tension of the liquid.

20 The cohesive forces between like molecules compete with external forces existing between the molecules of the liquid and molecules of the material contacting the liquid. When this material is hydrophobic, the cohesive forces significantly dominate, the free surface of the liquid becomes film-like and the liquid is incapable of wetting the hydrophobic material.

25 Referring now to the drawings, Figure 1 is a schematic illustration of aggregate 1, which preferably comprises a plurality of differently sized particulates 2 characterized by several (specifically selected) parameters which influence the level of the external forces and thereby the hydrophobic properties of the aggregate. These parameters includes, but are not limited to, a size distribution,  $M$ , of particulates 2, a  
30 contact angle,  $\theta$ , defined between the liquid and particulates 2 and a characteristic distance,  $r$ , defined between adjacent particulates.

$M$ ,  $\theta$  and  $r$  are preferably selected depending on the waterproofing application for which the aggregate is designed to be used, and in accordance with the maximal

liquid pressure expected in the specific application. More specifically,  $M$  and the cosine of  $\theta$  are preferably proportional to the pressure and  $r$  is preferably inversely proportional to the pressure. Mathematically, the relation between the maximal pressure,  $P$ , and the above parameters may be expressed using the following empirical formula:

$$P = k M \cos\theta / r, \quad (\text{EQ. 1})$$

where  $k$  is a constant of the proportionality and the angle,  $\theta$ , is measured from the tangent to a surface defined by the layer of the free-flowing aggregate. One ordinarily skilled in the art would appreciate that only when the right-hand-side of Equation 1 is positive, the aggregate is wetted by the liquid which may then percolate there through. Thus, according to a preferred embodiment of the present invention,  $\cos\theta$  is negative so that the aggregate remains dry at all times. This can be achieved by selecting  $\theta$  to be from  $90^\circ$  to  $180^\circ$ , where larger values of  $\theta$  within this range correspond to larger pressure under which the aggregate remains dry and *visé versa*.

The contact angle,  $\theta$ , depends on the materials from which the hydrophobic aggregate of the present invention is made. A detailed description of materials which were found to be suitable to various waterproofing applications is provided hereinafter.

A non-uniform size distribution allows for better control on the capillary size of aggregate 1. Capillary size is a measure of the diameter of capillaries formed between the particulates of the aggregate.

Thus, according to a preferred embodiment of the present invention the size distribution,  $M$ , is selected so that a maximal diameter of the capillaries is suitable for repelling the liquid at the pressure,  $P$ . One ordinarily skilled in the art would appreciate that the more  $M$  is non-uniform the smaller the size of the capillaries. A typical diameter of the capillaries is from 1 nanometer to 500 nanometers. Such diameter is size wise compatible with capillaries formed in concrete matrices.

Generally, the size of the particulates may vary between about 25 millimeters (25,000 microns) and 5 microns, more preferably between 10 millimeters and 20 microns, more preferably between 5 millimeters and 100 microns and most preferably between 1,000 microns and 200 microns.

In a construction site, large size particulates are easier to handle. Thus, depending on the application and the desired diameter of the capillary the manufacture can select the characteristic variance of the size distribution of the aggregate.

More specifically, in applications in which the expected column of liquid is not high (of the order of a few centimeters) it is sufficient to provide larger particulates and small variance, whereas if the expected column of liquid is higher (of the order a few meters) the particulates are preferably smaller in size and larger in variance. For example, for a column of liquid of about 50-100 cm the preferred variance is about 50 micrometers, for a column of liquid of about 1-10 m the preferred variance is about 30 micrometers and for a column of liquid of about 10-50 m the preferred variance is about 10 micrometers. It is to be understood that the above variances are representative examples and should not be considered as limiting.

Other physical quantities which can be affected by  $M$  include, but are not limited to, the specific weight of the aggregate, water absorption capability, thermal properties (e.g., thermal conductivity, specific heat capacity, latent heat) and acoustical isolation. Thus, by varying the size distribution,  $M$ , an application-oriented aggregate may be formed. For example, in an acoustical isolated waterproofing application  $M$  is selected so as to maximize the acoustical isolation of the aggregate, in temperature isolated waterproofing application  $M$  is selected so as to minimize the thermal conductivity of the aggregate, etc.

A judicious selection of the size distribution can also be used to control the ability of the aggregate to allow evaporation of the liquid there through. Evaporation of the liquid through the aggregate enhances the ability of the aggregate to maintain the environment dry and allows vapor passage and equilibrium of vapor pressure. This is in contrast to fully sealed waterproofing materials where the water is trapped inside the volume defined by the material. Hence, according to a preferred embodiment of the present invention,  $M$  is selected so that the aggregate is capable of allowing evaporation of the liquid.

One of ordinary skill in the art would appreciate that the above parameters which, as stated, are selected in accordance with the pressure to which the aggregate 1 is expected to be exposed, are static. In other words, the set of parameters, once selected, fix the pressure limits in which aggregate 1 can be effectively used. However, on some occasions, the pressure actually applying on aggregate 1 on site

exceeds the expected limits, *e.g.*, under extreme and unexpected weather conditions. In addition, being made of many particulates, aggregate 1 may exhibit statistical fluctuations in which locally the capillaries exceed their average size by several standard deviations. Furthermore, in interfaces between hydrophobic and non hydrophobic layers, a relatively large capillary size is typically formed. The problem of large interface capillaries is non statistical and affects the overall pressure under which aggregate 1 can be used. This problem may be solved by applying adhesives between hydrophobic and non hydrophobic layers, as further detailed herein under.

While reducing the present invention to practice it has been uncovered that the capillary size of aggregate 1 may be significantly reduced using inflatable particulates capable of absorbing fluid (*e.g.*, water). Once being in contact with the liquid, the inflatable particulates dynamically adjust to the liquid pressure, even when this pressure exceeds its expected value.

Due to the judicious selection of the static parameters of aggregate 1 (*e.g.*, the size distribution,  $M$ ), the inflatable particulates inflate only when the pressure exceeds the expected pressure to which aggregate 1 is designed. As the pressure rises, the inflatable particulates start to inflate thus establishing a dynamic pressure barrier. It will be appreciated that most waterproofing applications are performed in a closed space, so that the inflation of the inflatable particulates increases internal forces within aggregate 1, blocking residual capillaries and thus enhancing the ability of aggregate 1 to prevent percolation of liquid and passage of water vapor.

The inflatable particulates may be incorporated into aggregate 1 in more than one way. Hence, in one embodiment, the inflatable particulates may be integrated in, or attached to particulates 2, already in the manufacturing stage thereof. This embodiment is further detailed hereinafter, following the description of the suitable materials which may be used to manufacture aggregate 1.

In another embodiment, the inflatable particulates are in the form of free particulates (*e.g.*, a powder). Referring now again to Figure 1, an inflatable particulate 3 is present in void 4 between particulates 2. When a local increase of liquid occurs, particulates 2 are pressed one against its neighbors, while, at the same time, inflatable particulate 3 absorbs the liquid and begins to inflate, hence operates as a small "balloon" having a dynamically expanding surface area. External forces, caused by particulates 2 and acting inwards to void 4 limit the inflating process so that particulate

3 becomes a three-dimensional structure whose shape is similar to the shape of void 4. The inflating process is terminated when particulate 3 essentially occupies void 4, thus reducing the characteristic distance,  $r$ , and increasing the pressure,  $P$ , under which aggregate 1 is effective. When several such inflatable particulates are present in void 4, the filling of void 4 is more efficient.

According to a preferred embodiment of the present invention, the average size of inflatable particulates is selected so that, when the inflatable particulates are in deflated state, at least one inflatable particulate or, more preferably, several inflatable particulates, occupy void 4. In this embodiment, a typical size of the inflatable particulates is from about 1 micrometer to about 1000 micrometers, preferably, 5-500 micrometers.

Although more than one inflatable particulate may occupy the same void, the inflatable particulates preferably are devoid of any fluid communication there amongst, so that even when the inflatable particulates are in inflated state, the free-flowing nature of aggregate 1 is maintained. This may be accomplished, for example, if the inflatable particulates constitute a sufficiently small volume percentage of aggregate 1. Preferably, the inflatable particulates constitute less than 1 % of aggregate 1 by volume, more preferably about 0.2 %.

The voids between the hydrophobic surfaces of particulates 2 form a network, at least partially interconnected, in which the largest voids determine the entire behavior of aggregate 1. Thus, the incorporation of even a low percentage of inflatable particulates, results in a small residual number of large interconnected voids hence significantly improves the resistance of aggregate 1 to pressure.

According to a preferred embodiment of the present invention the swelling time of the inflatable particulates is sufficiently small (preferably under 10 seconds) so that aggregate 1 quickly responds to any contact with water. The absorption capability of the inflatable particulates is preferably from about 100 to about 5000 by weight, more preferably from about 200 to about 2000 by weight. The freezing temperature of the inflatable particulates is preferably below about  $-20^{\circ}\text{C}$  (both in inflated and in deflated states) so that aggregate 1 maintains its free-flowing nature even at low temperatures. A judicious selection of the material from which the inflatable particulates are made may result in that cycles of absorption-desorption thereof can be repeated endlessly.



Any material known capable of swelling when in contact with a liquid can be used for the inflatable particulates, provided that the combination of the inflatable particulates and particulates 2 maintains the free-flowing nature of aggregate 1. Representative examples for such materials include, but are not limited to, starch, clay, bentonite, water blockers of various types and the like. Additional characteristics of interest for the inflatable particulates include, without limiting, thermal isolation, liquid absorbency, sufficiently low freezing temperature, deflating ability in dry environment and the like.

According to a preferred embodiment of the present invention, the inflatable particulates are made of a super absorbent polymer (SAP), also known as Polyols polymers. SAPs are known in the art for many years. What makes SAP water absorbent is the presence of a chemical such as sodium or potassium molecules that cross-links between the hydrocarbon chains of a polymer. These cross-links allow the polymer to form into a single super-molecule capable of holding significant amounts of water. The polymer is typically polyurethane, urethane or polypropylene, but other polymers may also be used. There are hundreds types of SAPs, characterized by various parameters, such as their water pick-up capabilities, the temperature at which water is absorbed and desorbed, abruptness of water release and the like.

A representative example of a SAP include, without limitations, sodium cross linked with polyacrylic acid. Similar SAPs include, but are not limited to, LiquiBlock™ 80, LiquiBlock™ 88, LiquiBlock™ At-03S, LiquiBlock™ 80HS, LiquiBlock™ 88Hs, LiquiBlock™ 144, LiquiBlock™ 144TRS, Norsocryl™ S-35, Norsocryl™ D-60, Norsocryl™ XFS, all of which are purchasable from Emerging Technologies, Inc., North Carolina, USA. These SAPs were experimentally found to be suitable for incorporating with the aggregate 1. Other SAPs are presently manufactured by, and are available from, Union Carbide, BASF Corporation and many other companies.

According to a preferred embodiment of the present invention the inflatable particulates may comprise an anti-cracking agent to minimize liquid communication between adjacent inflatable particulates. For example, Norsocryl™ XFS and LiquiBlock™ 144TRS, above, include an anti-cracking agent.

Normally, without hydrophobic aggregates, large amount of SAP is needed for waterproofing or blocking the passage of water. This makes the use of SAP, difficult

and expensive. One of the advantages of this embodiment of the present invention is that the SAP is used only for the purpose of bridging between capillaries, while most of the waterproofing is accomplished by the inherent hydrophobic properties of aggregate 1. Thus, only a small amount of SAP is needed, as further detailed hereinabove.

In experiments made by the inventor of the present invention, it has been found that by adding an amount as small as 0.2 % of Norsocryl S-35 with an average particulate size of 100-500 micrometers, absorption capability of more than 500 by weight and swelling gelling time of about 6 seconds, significantly reduced the capillary size of aggregate 1. In particular, it has been found that the above-mentioned problem of the large capillaries between hydrophobic and non-hydrophobic layers was almost completely eliminated. The elimination or at least reduction of this problem is particularly useful in waterproofing applications in which object (e.g., pipes, tanks, etc.) lies within a hydrophobic layer. In such cases, there is a large surface contact between hydrophobic and non-hydrophobic layers.

It is anticipated that many types of inflatable particulates will be developed during the life time of this patent, and it is therefore within the scope of the present invention to include all such inflatable particulates *a-priori*.

According to a preferred embodiment of the present invention the hydrophobic aggregate may be mixed with lightweight aggregates, for example, Pumis, Perlite, volcanic aggregate, crashed foam concrete, etc. The lightweight aggregates serve for reducing the overall weight of the mixture. The reduced weight is important, for example, when the mixture is used for waterproofing roofs, flooring or any waterproofing done indoors.

For purposes of better understanding the use of the free-flowing hydrophobic aggregate in waterproofing applications in accordance with preferred embodiments of the present invention, reference is first made to a conventional (*i.e.*, prior art) method of waterproofing as illustrated in Figures 2A-B.

Referring now to the drawings, Figures 2A-B schematically illustrate prior-art methods of waterproofing a foundation of a structure 10 on a ground 12. In general, a foundation layer of pebbles 22, and sidewalls of pebbles 20 are provided as water channels to allow for water flow adjacent to underground section 14 of structure 10. Additionally, the foundation walls of underground section 14 may be covered with tar

or a similar material, as an additional water protection. However, when the water table is high (e.g., on rainy days or when a plumbing problem occurs), side pressure 16 and upward pressure 18 may nonetheless be applied to the foundation walls by the underground water, causing cracks and possibly penetrating underground section 14.

5 According to another aspect of the present invention there is provided a method of waterproofing a portion of a structure being in contact with a ground. The method comprises the following method steps in which in a first step a bed of a free-flowing hydrophobic aggregate is provided, and in a second step the structure is positioned over or in the bed. According to a preferred embodiment of the present invention any free-flowing hydrophobic aggregate may be used, such as, but not limited to, aggregate 1 mentioned hereinabove or another commercially available free-flowing hydrophobic aggregate (also known in the literature as "magic sand"), manufactured, for example, by Clifford W. Estes Co. Inc., New Jersey, USA, and Educational Innovations, Connecticut, USA. Yet, additional aggregates useable in context of the present invention are described in U.S. Provisional Patent Application Nos. 60/486,419 and 60/486,420, WO 03/044124 and U.S. Patent No. 4,474,852, all of which are hereby incorporated by reference.

Referring further to the drawings, Figures 3A-C schematically illustrate waterproofing of a foundation of a construction, in accordance with a preferred embodiment of the present invention. A bed 32 of free-flowing hydrophobic aggregate is applied over pebble layer 22, preferably remains as a drainage channel under bed 32. Bed 32 prevents water from applying upward pressure onto underground section 14. The hydrophobic aggregate may be delivered to the construction site either in a free-flowing form, or encapsulated in one or protective encapsulations. One example of such protective encapsulation is a hydrophobic brick, as further detailed herein under (see Figure 4A and the description that follows). Thus, according to a preferred embodiment of the present invention bed 32 may comprise an arrangement of hydrophobic bricks.

Referring to Figure 3B, bed 32 is preferably protected by a structure 23, for example, a concrete structure or a polymeric structure, to prevent erosion by underground water.

The thickness of bed 32 (designated d1 in Figure 3B) is preferably from about 1 cm to about 15 cm, more preferably from about 4 cm to about 10 cm. However, it

will be appreciated that, depending on specific needs, other values may similarly be used.

According to a preferred embodiment of the present invention, wall 15 of underground section 14 can also be waterproofed by providing a sidewall 30 of the free-flowing hydrophobic aggregate (*e.g.*, aggregate 1) adjacent to wall 15. Objects protruding from wall 15 (nails, metal wires, *etc.*) which may penetrate through the hydrophobic aggregate and allow water to flow thereupon from ground 12 into underground section 14 are preferably removed from wall 15, prior to the construction of sidewall 30 but further work on walls is not necessary contrary to prior art method in which the walls have to be carefully prepared to accept waterproofing.

Wall 15 is preferably coated by a waterproofing liquid or paste, *e.g.*, tar layer 24. Tar layer 24 (or any alternative waterproofing substrate covering wall 15) adheres the hydrophobic aggregate to wall 15 hence serves as a vapor barrier, preventing a formation of gap between sidewall 30 and wall 15. One would appreciate the advantage of preventing the formation of such a gap because water may flow into the gap from above.

With reference to Figure 3C, sidewall 30 of the hydrophobic aggregate is preferably protected by a structure 36, which may be, for example, one or more wood boards, polymeric (*e.g.*, polystyrene) boards, plastic boards, metal boards, a brick wall or a concrete structure. Structure 36 is interposed between sidewall 30 and ground 12 (or pebble layer 22) hence serves for protecting sidewall 30 from erosion, roots, rocks and the like. Preferably, structure 36 has a non-smooth surface 37, facing ground 12 or pebble layer 22 for so as to enlarge the contact area between structure 36 and the ground.

The construction of sidewall 30 may be done by more than one way, as further detailed herein below, both to a an existing structure, during repair procedure, and to a new structure, during its construction.

In existing structures, prior art methods typically include the use of foam or swollen materials injected along the existing walls into the interface between the wall and the ground surrounding the wall. In extreme cases the area near the underground wall is exposed or vacuumed using heavy machinery, so as to allow access to the external side of the wall. The wall is than waterproofed by a sealing material, such as

elastomeric concrete or various foams. These methods, however, are expensive, complicated, and fail to provide a long-term solution to the moisture problem.

According to a preferred embodiment of the present invention, underground wall 15 can be waterproofed by the following procedure. First, a layer of ground adjacent to the external side of wall 15 is pulled out or vacuumed, leaving a gap of air, and second the gap is filled with the free-flowing hydrophobic aggregate. The free-flowing nature of the hydrophobic aggregate allows for a substantially complete filling of the gap, in contrast to any other foamy or swollen material which does not allow an airflow there through, hence entrap air pockets and cannot fill the entire gap.

In new structures, structure 36 is preferably constructed adjacent to wall 15, in a manner that a gap is formed between structure 36 and wall 15. Subsequently, the gap is filled with the free-flowing hydrophobic aggregate, preferably from the top side, as further detailed hereinabove.

Structure 36 may be made in any way known in the art. Hence, in one embodiment, structure 36 may be an additional wall, *e.g.*, a brick-concrete wall. The advantage of this embodiment is that the additional wall maintains the hydrophobic aggregate in place for a prolonged period of time. Additional advantages of the additional wall include additional strength to the construction and an enhanced isolation (both thermal and acoustical).

In another embodiment, structure 36 may be made of tiles (*e.g.*, plastic tiles) having toothed edges, which fit into each other, tongue and groove fashion. This embodiment has the advantage of holding the hydrophobic aggregate on a first side of structure 36 and the ground on a second side of structure 36. The toothed edge tiles are further detailed herein under with reference to Figure 9.

In another embodiment, also suitable for new structures, side wall 30 is constructed level by level as follows. Hard boards or other boards, such as, but not limited to, metal, wood and plastic boards) are temporarily positioned adjacent to wall 15, so that a first side of the hard boards is facing wall 15 (again, leaving a sufficient gap there between) and a second side of the hard boards is facing the ground. The gap is filled with the free-flowing hydrophobic aggregate and the ground is allowed to contact the second side of the hard boards. Subsequently, the hard boards are pulled out, preferably upwards, and the procedure is repeated for the next level, preferably using the same hard boards. In this embodiment, to protect the hydrophobic

aggregate, protecting structure 36 is preferably positioned permanently between the hydrophobic aggregate and the ground. Alternatively, the hard boards may be used as protecting structure 36. The advantages of this embodiment are that (i) there is no need to build an additional wall near wall 15 and (ii) the filling of the gap is simpler as a relatively small volume is filled at each level.

In any of the above embodiments, the preferred thickness of sidewall 30 (designated d2 in Figure 3C) is from about 4 cm to about 10 cm. It is to be understood that other values may similarly be used, depending on the expected water pressure.

In an additional embodiment, also suitable for new structures, side wall 30 comprises an arrangement of hydrophobic bricks, each comprising a protective encapsulation having a predetermined shape and encapsulating a free-flowing hydrophobic aggregate.

Figures 4A-B schematically illustrate a hydrophobic brick 40 having a protective encapsulation 41 and a hydrophobic brick wall 42. According to a preferred embodiment of the present invention encapsulation 41 is made from a bio degradable material or water degradable material, for example, recycled cardboard devoid of water protection and the like. In this embodiment, the construction of hydrophobic brick wall 42 is by positioning bricks 40 one on top of the other, similarly to the construction of any other brick wall. In time, when encapsulation 41 degrades, the hydrophobic aggregates of adjacent hydrophobic bricks are partially mixed, so that a substantially waterproof sidewall is formed. Once completed, wall 42 is preferably watered in order to facilitate the degrading of bricks.

One or more layers of bricks may be used. Preferably, the brick thickness, in the direction of water protection, d3, is about 2-10 cm, preferably about 4 cm. It will be appreciated that other dimensions may similarly be used.

It is known that structures in contact with the ground are dynamic, due to ground movements or crack formations. Thus, according to a preferred embodiment of the present invention, irrespectively of the method by which sidewall 30 (or brick wall 42) are constructed, a removable cover 38 is preferably provided on the top side thereof, to allow the refill of the gap, with time. Removable cover 38 may be made from any water resistant material, such as, but not limited to, waterproofed concrete stones.

Referring further to the drawings, Figures 5A-B schematically illustrate methods of waterproofing floors 60 of structure 10, in accordance with a preferred embodiment of the present invention.

Structure 10 includes several levels 70 and side walls 52. Bed 32 of hydrophobic aggregate (*e.g.*, aggregate 1) is applied under floors 60 and prevents water from collecting under the floor. A typical thickness of bed 32 for this aspect of the invention is about 1-10 cm, however, it will be appreciated that other values may similarly be used. Contact area 52' between wall 52 and bed 32 is preferably coated by a waterproofing liquid or paste which adheres the hydrophobic aggregate to wall 52 hence serves as a vapor barrier, as further detailed hereinabove.

A pipe 68 (*e.g.*, water, sewage, gas, electricity, *etc.*), if existing, may be embedded in bed 32, for example, under floor 60. The advantage of the hydrophobic aggregate is that it allows water to evaporate there through without becoming wet. Thus, if, for example, leakage occurs from pipe 68, once such leakage is repaired and excessive water is sponged or removed, the hydrophobic aggregate remains dry, thus avoiding situations of wet floors, mildew and health related implications of wetness. This advantage is not found in prior art methods where the water is trapped under the floor for a long time. A particular advantage of the present embodiment is that due to the improved isolating properties of the free-flowing aggregate, no additional isolating materials are necessary for the pipes as is commonly used for hot water pipes or the like. In addition, the free-flowing aggregate protects the pipes also from corrosion and wear.

Another advantage of using bed 32 under floor 60, is that such an environment keeps away insects and other organisms which cannot dig holes or tunnels, or even survive in the dry environment of the hydrophobic aggregate.

An additional advantage is the thermal and acoustical isolation provided by bed 32. Thus, for example, bed 32 is ideal as a bed for placing hot/cold water pipes, for which it will be appreciated that thermal isolation is of utmost important.

Reference is now made to Figures 6A - 6B which schematically illustrate prior art methods of waterproofing a roof 50. Numerous methods are known for waterproofing roofs. One such method is illustrated in Figure 6A, where a layer 54 of tar is applied to roof 50. Another method is illustrated in Figure 6B, where a layer of ordinary sand 58 and flooring 60 is applied onto roof 50. Additionally, protective

sheets 56, for example bituminous membranes, polyvinyl chloride (PVC) or ethylene propylene diene monomer (EPDM) layers may be used under layer of sand 58. However, none of these are fully satisfactory, and water problems from roofs, in particular flat roofs, are common.

5       The present invention successfully and advantageously addresses the issue of waterproofing a roof. Figure 7 schematically illustrates structure 10 having a roof 50 and sidewalls 52.

10       According to a preferred embodiment of the present invention, bed 32 of hydrophobic aggregate (*e.g.*, aggregate 1) is applied onto roof 50 and remains contained by sidewalls 52. Preferably, prior to the application of bed 32, the contour of roof 50 may be treated by providing vapor barrier and inclined edges, as is well known in the art. Additionally, floor 60 may be applied over bed 32, thus preventing erosion thereof. In this manner, a high-level water-proofing protection is achieved even on severe weather conditions such as hail. The thickness of bed 32 (designated  
15   d4 in Figure 7) is preferably about 5 cm. It will be appreciated that other values may similarly be used.

      According to an additional aspect of the present invention, there is provided a method of waterproofing a reservoir, *e.g.*, a water reservoir.

20       Referring further to the drawings, Figure 8 schematically illustrates a reservoir 80 having a base 82 and walls 88, which may be sloping walls or vertical walls. According to a preferred embodiment of the present invention, the method comprises the following method steps in which in a first step a flooring bed 84 of a free-flowing hydrophobic aggregate (*e.g.*, aggregate 1) is placed over base 82 of the reservoir. In a second step, walls 90 (sloping walls or vertical, depending on the shape of reservoir  
25   80) of the hydrophobic aggregate are placed over walls 88. Flooring bed 84 and/or walls 90 are preferably covered by protective structure 86 and 92, respectively, so as to maintain free-flowing hydrophobic aggregate in place. Preferably, a minimal depth of about 5-10 cm is maintained between structure 86 and base 82 and between structure 92 and walls 88 for the hydrophobic aggregate.

30       Structure 86 (covering bed 84) preferably comprises a flexible layer, for example, a geotechnic fabric, covered by a concrete slab, of preferably about 5 cm in thickness. Alternatively, the flexible layer of structure 86 may be covered by concrete tiles. Still alternatively, a portion of the flexible layer of structure 86 may be covered



by concrete tiles and another portion may be covered by a concrete slab. According to a preferred embodiment of the present invention the concrete is poured on the flexible layer devoid of metal wiring, to prevent flowing of the hydrophobic aggregate during the construction of structure 86. Polymeric fibers may be added to the concrete mix to minimize crack formations in the structure 86. The pouring of the concrete may be done in any way known in the art, preferably by leaving a sufficient number of gaps to allow the concrete to expand during its curing process.

Structure 86 may also be made of a plurality of protective boards or any other method known in the art.

The method for placing walls 90 depends on the shape of walls 88 of reservoir 80. For vertical walls, walls 90 may be constructed similarly to walls 30 or 42 as further detailed hereinabove.

For sloping walls, a sloping structure 92 is constructed. This may be done, for example, by placing various stabilizing means, such as, but not limited to, nets or nets covered with cloth, and then pouring the free-flowing hydrophobic aggregate from above. As stated, the hydrophobic aggregate allows air to flow there through without formation of air pockets.

Figure 9 schematically illustrates a representative example of stabilizing means, in the form of tiles 98 with toothed edges 99, which fit into each other, tongue and groove fashion. Tiles 98 may be made from polyvinyl chloride, polycarbonate or any other suitable material capable of holding the hydrophobic aggregate. The size and strength of the tiles is preferably selected so as to allow the installer to walk or stand thereon. Several elongators 97 (*e.g.*, screws) are preferably attached to the tiles so as to create a sufficient gap between the tiles and the ground. A typical length of elongators 97 is 1-10 cm.

The procedure of constructing sloping structure 92 using tiles 98 is as follows. A first line of tiles is arranged on sloping wall 88 near base 82, so that elongators 97 keep tiles 98 above the walls. The volume defined by elongators 97 is then filled with the hydrophobic aggregate. According to a preferred embodiment of the present invention tiles 98 may be manufactured from a transparent material so as to allow the installer to verify that the entire volume is filled, and to vibrate the tiles if necessary, so as to better distribute the hydrophobic aggregate. Mechanic or sonic vibration may also be used. Once the first line is filled with the hydrophobic aggregate, a second line

is arranged adjacent to the first line, and the procedure is repeated. According to a preferred embodiment of the present invention, once a line of tiles is filled, the elongators of the previous line are removed so as to allow the hydrophobic aggregate to fill the volume engaged by the elongators.

5        Once wall 88 is covered by tiles 98 and the hydrophobic aggregate, concrete or another suitable cover is preferably be applied on the other side of tiles 98. Toothed edges 99 serve for increasing the surface area of tiles 98 so as to maintain the hydrophobic aggregate and the concrete in place and to allow spray shot crating if so desired. The upper line of tiles is preferably permanently attached to the ground to  
10    serve as a protective cover.

      According to a preferred embodiment of the present invention the tiles are arranged in a manner that allows refilling of the free-flowing hydrophobic aggregate with time. This can be done, for example, by leaving openings in the upper line of tiles or by providing a removable cover thereupon, as further detailed hereinabove.

15        According to a further aspect of the present invention there is provided a method of protecting an object buried underground.

      Figure 10, schematically illustrate an object 100 (e.g., a pipe, a storage gas tank, an underground tunnel, underground wires and connection boxes, general storage tank, etc.) surrounded by ground 12. According to a preferred embodiment of the  
20    present invention the object is surrounded by a layer 102 of free-flowing hydrophobic aggregate (e.g., aggregate 1) in a manner that the layer of free-flowing hydrophobic aggregate is interposed between the object and the ground.

      One would appreciate the numerous advantages of using the hydrophobic aggregate as a protective layer.

25        First, being substantially dry, the hydrophobic aggregate serves as an electric isolator, thereby preventing electrolytic processes (such as electrolytic corrosion) from occurring near object 100. Even in cases where water vapors percolate upwards through layer 102, these are not sufficient to initiate electrolytic corrosion. In addition, as the hydrophobic aggregate has substantially no electrical conductivity,  
30    underground wires and connection boxes may be filled by hydrophobic aggregate, thereby preventing moisture from percolating. The free-flowing form hydrophobic aggregate facilitate the removal of the aggregate from the wires and/or the connection boxes, if such a removal is needed, e.g., for maintenance.

Second, various materials, and especially digesting materials, present in the ground in solid state are prevented from becoming liquefied and therefore from reaching and damaging object 100.

Third, the free-flowing form of the hydrophobic aggregate minimizes axial stresses from acting upon object 100. In other words, although being made of solid particulates, in terms of dynamical properties, the free-flowing hydrophobic aggregate is similar to a viscous fluid, which uniformly distributes the mechanical forces acting thereupon. Thus, the hydrophobic aggregate absorbs a considerable amount of the mechanical forces, thereby it protects object 100.

Forth, being substantially water-free, the hydrophobic aggregate does not freeze and does not stick, hence facilitate an easy access to object 100 in cold regions, and improves resistance to frost.

Following are representative examples of preferred hydrophobic aggregates suitable for the various applications of the present invention, as detailed hereinabove.

In a search for hydrophobic aggregates with improved performances, the present inventor has found that hydrophobic particulates that include as the hydrophobic coat a hydrophobic powder of one or more impure elements having one or more hydrocarbons attached thereto, optionally in combination with the commercially available hydrophobic fumed silica, can be prepared in an environmental-friendly and economically-efficient process and exert superior water-repellency as well as durability toward parameters such as high water pressures, dynamic water wear and reactive detergents.

Hence, according to a preferred embodiment of the present invention, the plurality of differently sized particulates of the free-flowing hydrophobic aggregate comprises a particulated core material coated by a hydrophobic powder, which comprises one or more impure elements having a hydrocarbon chain attached thereto.

As stated, the capillary size of the free-flowing aggregate may be significantly reduced using inflatable particulates capable of absorbing fluid. According to a preferred embodiment of the present invention the hydrophobic powder comprises inflatable particulates as further detailed hereinabove. In this embodiment, a preferred diameter of the inflatable particulates is from about 1 micrometer to about 100 micrometers.

As used herein, the phrase "impure element" includes chemical elements of the periodic table which are not used in their pure form.

The impure elements can be naturally impure elements such as, for example, oxidized elements or carbonated elements or can be pure or impure elements which have been further impurified by, for example, small quantities of other elements and/or various organic substances. The impurity of the element(s) is required so as to render the element susceptible to a surface reaction with an organic substance bearing the hydrocarbon chain, as is further detailed herein below.

The selected elements are preferably metallic, semi-metallic or transition metallic elements. Representative examples of preferred elements that are usable in context of the present invention, in an impure form, include, without limitation, magnesium, calcium, aluminum, zinc, sodium, barium, zirconium, manganese, titanium, vanadium, chromium, iron and combinations thereof. The elements are selected according to the desired application of the final hydrophobic product. Specifically, for the applications taught by the present invention, hydrophobic powder that includes impure calcium, magnesium and/or zinc bearing a hydrocarbon chain is preferable.

As used herein, the phrase "hydrocarbon chain" describes a chain of carbon atoms that are covalently attached there between and are substituted by hydrogen atoms. The hydrocarbon chain can be linear or branched, saturated or unsaturated chain and therefore can be in the form of alkylene chains that are optionally interrupted or substituted by, for example, one or more aryl groups. The hydrocarbon chain of the present invention includes at least 10 carbon atoms, preferably at least 12 carbon atoms or more, *e.g.*, 13, 14, 15, 16, 17, 18, 19, 20 or more carbon atoms. Evidently, such a hydrocarbon chain is highly hydrophobic and therefore, when used for coating, renders the powder hydrophobic.

The hydrocarbon chain can be attached to the impure element(s) via various interactions such as electrostatic interactions and Van der Waals interactions. However, the hydrocarbon chain is preferably covalently attached to the element(s), to thereby form a hydrophobic derivative of the element.

Hence, a preferred hydrocarbon chain according to the present invention is a residue of a hydrophobic organic substance that is capable of reacting with the impure element(s). Such an organic substance has a functional group that can react with the

surface of an impure element, the functional group is connected to the hydrocarbon chain.

A representative example of such an organic substance is a fatty acid that has at least 12 carbon atoms. Fatty acids can react with various functional groups that are present on the impure elements' surface via its carboxylic end, to thereby provide the hydrophobic derivative described above. Representative examples of fatty acids that are usable in context of the present invention include, without limitation, stearic acid, lauric acid, myristic acid, palmitic acid, oleic acid, linolenic acid and arachidonic acid.

Hence, the hydrophobic powder of the present invention preferably includes an impure element or a mixture of impure elements, as is defined hereinabove, whereby the selected impurity renders the surface of the element(s) susceptible to chemically reacting with the organic substance described above, which have been reacted with the organic substance to thereby provide the impure element(s) having the hydrocarbon residue of the organic substance covalently attached thereto.

A representative example of a hydrophobic powder that is usable in context of the present invention therefore includes, without limitations, a powder obtained by surface reaction of oxidized element(s) (e.g., colloidal particles of calcium oxide, magnesium oxide and the like), which bear free hydroxyl groups on their surfaces, and a fatty acid such as, for example, stearic acid. The free hydroxyl groups react with the carboxylic group of the fatty acid, so as to form the corresponding ester.

Another representative example of a hydrophobic powder that is usable in context of the present invention include, without limitations, a powder obtained by surface reaction of a carbonated element (e.g., calcium carbonate), which is further impurified with oxidized elements such as magnesium oxide and iron oxide, as well as other substances such as, for example, silicates and sulfates, and a fatty acid as is described hereinabove.

A powder prepared by reacting the surface of calcium carbonate, which have been further impurified with stearic acid, is commercially available (for example, from Kfar-Gilaadi Quarries, Israel). However, this powder has never been used as a hydrophobic powder for waterproofing and is presently used in the pharmaceutical industry as well as in the plastic industry.

The hydrophobic powder of the present invention is typically characterized by a surface area ranging between 1 m<sup>2</sup>/gr and 20 m<sup>2</sup>/gr. However, in cases where higher

surface area is required, the hydrophobic powder can be grinded so as to enhance the surface area up to more than 50 m<sup>2</sup>/gr (e.g., 60 m<sup>2</sup>/gram). It should be noted in this respect that the presently known hydrophobic coatings, e.g., the hydrophobic coatings described in U.S. patent No. 4,474,852 and in WO 03/044124, are characterized by surface areas of about 50 m<sup>2</sup>/gram.

Due to its particular chemical structure, the hydrophobic powder of the present invention exerts "soap-like" properties and hence it is further characterized as being inactive toward alkaline reagents, such as detergents. Once again it should be noted in this respect that the presently known hydrophobic coatings that are based on hydrophobic colloidal oxides are characterized as being susceptible to such reagents and hence cannot be used in applications that involve the use of detergents.

The hydrophobic powder of the present invention has an average particles size ranging between 0.1 micron and 50 microns, preferably between 0.1 micron and 20 microns, and more preferably between 0.1 micron and 10 microns.

According to a preferred embodiment of the present invention, the hydrophobic powder may further comprise hydrophobic fumed silica.

As used herein, the phrase "hydrophobic fumed silica" describes a colloidal form of silica made by combustion of silicon tetrachloride in hydrogen-oxygen furnaces, in which individual particles on the surface thereof have been chemically bonded to hydrophobic trimethoxysiloxyl groups. Hydrophobic fumed silica is a commercially available powder typically having an average particles size smaller than 1 micron and, if present in the hydrophobic powder of the present invention, it can constitute between 1 and 99 weight percentages of the powder. The resulting mixed powder typically has an average particle size of between 0.1 micron and 20 microns.

Hence, preferred hydrophobic particulates according to the present invention include a particulated core material that is coated by a combination of the hydrophobic powder described hereinabove and hydrophobic fumed silica, whereas the partial amount of each of these powders is predetermined either by the selected core material and/or by the intended use of the final product. For example, in applications that require high water repellency, the hydrophobic particulate should generally have smaller particles size and hence the mixed powder consists a higher amount of the hydrophobic fumed silica. In applications that require lower water-repellency, the

hydrophobic particulate can generally have larger particles size and hence the mixed powder consists a higher amount of the hydrophobic powder described hereinabove.

The use of a minimal amount of hydrophobic fumed silica is highly advantageous as it substantially reduces the cost of the final product.

5 In any event, the hydrophobic powder of the present invention, alone or in combination with hydrophobic fumed silica, constitutes between about 0.1 and 5 weight percentages of the hydrophobic particulate, whereby powders that include higher amount of the hydrophobic powder described hereinabove constitute between about 2 and about 5 weight percentages of the final particulate composition and  
10 powders that include higher amount of the hydrophobic fumed silica constitute between about 0.1 and about 2 weight percentages of the final particulate composition.

The particulated core material coated by the hydrophobic powder of the present invention may be selected from a wide variety of organic and inorganic substances, with inorganic substances (e.g., minerals) being favored from standpoint of cost and  
15 availability. Representative examples of particulated core materials that are preferably usable in context of the present invention include, without limitation, sand, gravel, slag, porcelanit, dolomite, porcelain, basalt, quartz sand, coal ash, chalk, zeolite, montmorillonite, agapultite, flint, bentonite, perlite, mica, wood chips, nut shells, sawdust and combinations thereof.

20 The hydrophobic particulate of the present invention preferably further comprises an adherent layer, which bonds the hydrophobic powder to the particulated core material. The adherent layer serves as a first coat layer deposited on the core material, which anchors the hydrophobic outer coat thereto.

The adherent layer preferably comprises a film forming agent such as a film  
25 forming polyurethane. Any of the film-forming polyurethanes commonly employed in the field of coatings may be used in the practice of the present invention. Included in this category are the well-known two-component and one-component polyurethane coating systems. The two-component systems are formed by the reaction of an aliphatic or aromatic isocyanate with a hydroxyl-bearing compound, such as  
30 polyfunctional polyesters based on adipic acid, phthalic anhydride, ethylene glycol and trimethylolpropane, for example. Representative of the one-component polyurethane coating systems that may be employed as the adherent layer are those derived from stable isocyanate-terminated prepolymers formed from an aliphatic or aromatic

isocyanate and polyfunctional polyether or polyester. These one-component systems are commonly referred to as "moisture cured" polyurethane coatings because drying results from the reaction of the free-isocyanate groups of the pre-polymer with water or atmospheric moisture. Another one-component polymer coating which may be  
5 used in the preparation of the hydrophobic particulates is the "urethane oil" or "uralkyd", which is the reaction product of a diisocyanate with a hydroxyl-containing drying oil derivative, e.g., that produced by alcoholysis of an unsaturated glyceride with a polyol, such as trimethylolpropane.

10 The adherent layer of the present invention may further comprise a gluing agent in combination with the film-forming agent, so as to provide an increase in the anchoring quality of the adherent layer over a longer period of time and an increased attraction for oil and oil related products. Hence, the presence and the relative amount of the gluing agent depend on the need of such properties, in accordance with the intended application of the final product.

15 The gluing agent preferably comprises a volatile hydrocarbon that has at least 12 carbon atoms, such as, for example, asphalt.

As used herein, the term "asphalt" describes a dark brown to black cementitious material in which the predominate constituents are bitumens that occur in nature or are obtained in petroleum processing, the latter being preferred, primarily  
20 because of its greater availability. The asphalt may be solid, semi-solid or liquid, with the latter being preferred.

However, other gluing agents, such as, for example, paraffin wax, beeswax, lanolin wax, linseed oil and any other commercially available wax, can be used in this context of the present invention, though their relative amount in the adherent mixture  
25 is preferably lower than that of the asphalt.

The adherent layer of the present invention preferably constitutes between about 0.5 and about 7 weight percentages of the hydrophobic particulate, more preferably between 1 and 5 weight percentages of the hydrophobic particulate, depending on the particles size of the particulated core material, the selected process  
30 of preparing the hydrophobic particulate and the intended application of the final product. For example, in cases where the particulated core material has an average particles size ranging between 150 microns and 1000 microns, a smaller amount of the adherent layer, e.g., between 0.5 and 1 weight percentage of the hydrophobic



particulate, is used. In cases where the particulated core material has particles larger than 1000 microns or smaller than 150 microns, a higher amount of the adherent layer is preferred. Using a higher amount of the adherent layer (e.g., more than 1 weight percentage of the particulate, preferably 2 weight percentages) results in particulates enriched with "free particles", which are characterized by enhanced resistance to dynamic wear. Also, higher amount of adherent layer (e.g., between 3 and 7 weight percentages of the particulate) is required in cases where the hydrophobic particulate is prepared in a "cold" process, as is detailed herein below.

The adherent layer of the present invention is easily applied to the particulated core materials by dissolving the film-forming agent and the gluing agent, if present, in a volatile solvent, so as to form a homogeneous composition and to provide a uniform deposition of the adherent layer over the surfaces of the core materials. As is described in detail herein below, such an adherent layer mixture is mixed with the core material while the volatile solvent is evaporated.

Preferred compositions of the adherent layer mixture include a film-forming polyurethane in an amount ranging between 5 and 25 weight percentages of the adherent layer mixture, depending on the size and type of the core material; a gluing agent in an amount ranging between 0 and 25 weight percentages of the adherent layer mixture, depending on the core material used, the gluing agent used and the intended use of the final product; and a volatile solvent in an amount of between 50 and 95 weight percentages of the mixture, depending on the amounts of the other components.

As the volatile solvent merely functions as a vehicle for depositing the adherent layer on the core materials, virtually any volatile solvent in which the components of the adherent layer are soluble may be used. However, preferred solvents include petroleum distillates, such as mineral spirits or paint thinner, which have a boiling temperature of between about 80 °C and about 200 °C. A representative example of a preferred volatile solvent is toluene, which is readily evaporated at relatively low temperatures and results in rapid spread of the mixture onto the core materials.

The hydrophobic particulates of the present invention can further comprise various additives which, in accordance with the intended application and the core material used, provide hydrophobic particulates with improved characteristics.

Representative examples of such additives include, without limitations, coloring agents, UV resistant agents, bleaching agents and abrasive agents.

Coloring agents that are usable in context of the present invention include any of the presently known mineral or organic coloring agents, with mineral coloring agents being preferred. A preferred amount of the coloring agent ranges between about 0.1 and 2 weight percentages of the hydrophobic particulate.

The resulting colored hydrophobic particulates may be beneficially used in various applications, such as applications that require easy identification of the hydrophobic particulate or applications that involve external coating. A representative example of such an application is the use of colored hydrophobic sand to mark submerged cables, so as to warn against excavation nearby. The addition of a coloring agent to the hydrophobic particulate is further beneficial as it can sometimes improve the surface tension of the product, thus rendering it more hydrophobic.

UV resistant agents are added to the hydrophobic particulates of the present invention in order to improve the durability of the products against UV irradiation, and are hence particularly useful in applications such as the above mentioned waterproofing of roofs. Representative examples of UV resistant agents that are usable in context of the present invention include, without limitation, titanium dioxide and zinc oxide, both may also serve as bleaching agents. A preferred amount of the UV resistant agent and the bleaching agent ranges between about 0.01 and 2 weight percentages of the hydrophobic particulate.

Abrasive agents are typically added to the hydrophobic particulate in order to improve the wear resistance of the particulates and are therefore typically used in applications where the particulates are exposed to continuous wear, such as protection of buried objects and the like. Representative examples of abrasive agents that are usable in context of the present invention include, without limitation, powdered abrasives such as titanium dioxide and aluminum oxide ( $Al_2O_3$ , corundum). A preferred amount of the abrasive agent ranges between about 0.1 and 0.25 weight percentages of the hydrophobic particulate.

Thus, the preferred particulates of the present invention are comprised of a particulated core material, which is coated by the hydrophobic powder, preferably in combination with hydrophobic fumed silica, and preferably further include an adherent layer, as further detailed hereinabove. Optionally, the hydrophobic particulates of the

present invention further comprise additives for improving their properties in accordance with their intended application.

A representative example of a hydrophobic particulate according to the present invention is quartz sand coated by a mixture of the hydrophobic powder described  
5 herein and hydrophobic fumed silica, in a ratio that ranges between 20:1 and 2:1, whereby this hydrophobic mixture is bonded to the sand via an adherent layer.

The hydrophobic particulates of the present invention are superior to the presently known hydrophobic aggregates as they include inexpensive and available materials, they are characterized as inactive toward alkaline reagents such as  
10 detergents, and they exert superior water-repellency and are further characterized as being capable of preventing water adherence thereto and water penetration therein under an external pressure of at least 3 atmospheres and up to almost 5 atmospheres, and as being highly durable toward dynamic water wear, namely, as remaining hydrophobic under continuous dynamic water wear for at least two months.

15 It is appreciated that certain features of the invention, which are, for clarity, described in the context of separate embodiments, may also be provided in combination in a single embodiment. Conversely, various features of the invention which are, for brevity, described in the context of a single embodiment, may also be provided separately or in any suitable subcombination.

20 Although the invention has been described in conjunction with specific embodiments thereof, it is evident that many alternatives, modifications and variations will be apparent to those skilled in the art. Accordingly, it is intended to embrace all such alternatives, modifications and variations that fall within the spirit and broad scope of the appended claims. All publications, patents and patent applications  
25 mentioned in this specification are herein incorporated in their entirety by reference into the specification, to the same extent as if each individual publication, patent, or patent application was specifically and individually indicated to be incorporated herein by reference. In addition, citation or identification of any reference in this application shall not be construed as an admission that such reference is available as prior art to  
30 the present invention.

## WHAT IS CLAIMED IS:

1. A free-flowing hydrophobic aggregate capable of repealing a predetermined maximal pressure of liquid, the free-flowing hydrophobic aggregate comprising a plurality of differently sized particulates, wherein at least one of a size distribution of said particulates, a contact angle between the liquid and said particulates and a characteristic distance between adjacent particulates is selected so that when a layer of the free-flowing hydrophobic aggregate is in contact with a liquid having a pressure lower than or equal to the predetermined maximal pressure, percolation of the liquid through the free-flowing hydrophobic aggregate is prevented.
2. The free-flowing hydrophobic aggregate of claim 1, wherein the liquid is water.
3. The free-flowing hydrophobic aggregate of claim 1, wherein said layer has a thickness from about 1 cm to about 10 cm and further wherein the predetermined maximal pressure is equivalent to a column of water having a height above 30 cm.
4. The free-flowing hydrophobic aggregate of claim 1, wherein said layer has a thickness from about 1 cm to about 10 cm and further wherein the predetermined maximal pressure is equivalent to a column of water having a height above 100 cm.
5. The free-flowing hydrophobic aggregate of claim 1, wherein said size distribution is characterized by a variance ranging from 1 micrometer to 1400 micrometer.
6. The free-flowing hydrophobic aggregate of claim 1, wherein said size distribution is selected so that a maximal diameter of capillaries formed between said particulates is suitable for repealing the predetermined maximal pressure of the liquid.
7. The free-flowing hydrophobic aggregate of claim 1, wherein said size distribution is selected so that a maximal diameter of capillaries formed between said particulates is from 1 nanometer to 500 nanometers.

8. The free-flowing hydrophobic aggregate of claim 1, further comprising inflatable particulates size wise compatible with capillaries formed between said particulates and capable of absorbing the fluid.

9. The free-flowing hydrophobic aggregate of claim 8, wherein an absorption capability of said inflatable particulates is from about 100 to about 5000 by weight.

10. The free-flowing hydrophobic aggregate of claim 8, wherein a freezing temperature of said inflatable particulates below about -20 degrees centigrade, both in an inflated state and in a deflated state of said inflatable particulates.

11. The free-flowing hydrophobic aggregate of claim 8, wherein said inflatable particulates, when in a deflated state, constitute less than 2 percent of the free-flowing hydrophobic aggregate by volume.

12. The free-flowing hydrophobic aggregate of claim 8, wherein a diameter of said inflatable particulates is from about 1 micrometer to about 1000 micrometers.

13. The free-flowing hydrophobic aggregate of claim 8, wherein said inflatable particulates comprise a super absorbent polymer.

14. The free-flowing hydrophobic aggregate of claim 8, wherein said inflatable particulates comprises sodium being cross linked with polyacrylic acid.

15. The free-flowing hydrophobic aggregate of claim 8, wherein said inflatable particulates comprises anti-cracking agent.

16. The free-flowing hydrophobic aggregate of claim 1, wherein said size distribution is selected so that the free-flowing hydrophobic aggregate is characterized by a predetermined specific weight.

17. The free-flowing hydrophobic aggregate of claim 1, wherein said size distribution is selected so that the free-flowing hydrophobic aggregate is characterized by a minimal water absorption capability.

18. The free-flowing hydrophobic aggregate of claim 1, wherein said size distribution is selected so that the free-flowing hydrophobic aggregate is characterized by predetermined thermal properties.

19. The free-flowing hydrophobic aggregate of claim 18, wherein said predetermined thermal properties are selected from the group consisting of thermal conductivity, specific heat capacity and latent heat.

20. The free-flowing hydrophobic aggregate of claim 1, wherein said size distribution is selected so that the free-flowing hydrophobic aggregate is characterized by predetermined acoustical isolation ability.

21. The free-flowing hydrophobic aggregate of claim 1, wherein said size distribution is selected so that the free-flowing hydrophobic aggregate is capable of allowing evaporation of the liquid.

22. The free-flowing hydrophobic aggregate of claim 1, wherein said size distribution is proportional to the predetermined maximal pressure.

23. The free-flowing hydrophobic aggregate of claim 1, wherein a cosine of said contact angle is proportional to the predetermined maximal pressure, said contact angle is measured from a tangent to a surface defined by the free-flowing hydrophobic aggregate.

24. The free-flowing hydrophobic aggregate of claim 1, wherein said characteristic distance is inversely proportional to the predetermined maximal pressure.

25. The free-flowing hydrophobic aggregate of claim 1, wherein said plurality of differently sized particulates comprises a particulated core material coated by a hydrophobic powder selected so as to provide said contact angle.

26. The free-flowing hydrophobic aggregate of claim 25, wherein said hydrophobic powder comprises at least one impure element having a hydrocarbon chain attached thereto.

27. The free-flowing hydrophobic aggregate of claim 26, wherein said hydrocarbon chain is covalently attached to said at least one impure element.

28. The free-flowing hydrophobic aggregate of claim 27, wherein said hydrocarbon is a residue of a fatty acid.

29. The free-flowing hydrophobic aggregate of claim 25, wherein said hydrophobic powder is bonded to said particulated core material via an adherent layer.

30. The free-flowing hydrophobic aggregate of claim 25, wherein said hydrophobic powder comprises inflatable particulates capable of absorbing the fluid.

31. The free-flowing hydrophobic aggregate of claim 30, wherein a diameter of said inflatable particulates is from about 1 micrometer to about 100 micrometers.

32. The free-flowing hydrophobic aggregate of claim 30, wherein an absorption capability of said inflatable particulates is from about 100 to about 5000 by weight.

33. The free-flowing hydrophobic aggregate of claim 30, wherein a freezing temperature of said inflatable particulates is below about -20 degrees centigrade, both in an inflated state and in a deflated state of said inflatable particulates.

34. The free-flowing hydrophobic aggregate of claim 30, wherein said inflatable particulates, when in a deflated state, constitute less than 1 percent of the free-flowing hydrophobic aggregate by volume.
35. The free-flowing hydrophobic aggregate of claim 30, wherein said inflatable particulates comprise a super absorbent polymer.
36. The free-flowing hydrophobic aggregate of claim 30, wherein said inflatable particulates comprises sodium being cross linked with polyacrylic acid.
37. The free-flowing hydrophobic aggregate of claim 30, wherein said inflatable particulates comprises anti-cracking agent.
38. The free-flowing hydrophobic aggregate of claim 25, wherein said particulated core material is selected from the group consisting of sand, gravel, slag, porcelanit, dolomite, porcelain, basalt, quartz sand, coal ash, chalk, zeolite, montmorillonite, agapultite, flint, bentonite, perlite, mica, wood chips, nut shells, sawdust and combinations thereof.
39. The free-flowing hydrophobic aggregate of claim 29, wherein said adherent layer comprises a film-forming agent.
40. The free-flowing hydrophobic aggregate of claim 39, wherein said adherent layer further comprises a gluing agent.
41. The free-flowing hydrophobic aggregate of claim 25, wherein said hydrophobic powder further comprises hydrophobic fumed silica.
42. The free-flowing hydrophobic aggregate of claim 25, further comprising at least one additive selected from the group consisting of a coloring agent, a UV resistant agent, a bleaching agent and an abrasive agent.



43. A hydrophobic brick comprising a protective encapsulation having a predetermined shape, and a free-flowing hydrophobic aggregate being encapsulated in said protective encapsulation.

44. The hydrophobic brick of claim 43, wherein said protective encapsulation is made from a degradable material.

45. The hydrophobic brick of claim 43, wherein said free-flowing hydrophobic aggregate comprises a plurality of differently sized particulates, and further wherein at least one of a size distribution of said particulates, a contact angle between a liquid and said particulates and a characteristic distance between adjacent particulates is selected so that when the free-flowing hydrophobic aggregate is in contact with a liquid having a pressure lower than or equal to a predetermined maximal pressure, percolation of the liquid through the free-flowing hydrophobic aggregate is prevented.

46. The hydrophobic brick of claim 45, wherein said size distribution is selected so that a maximal diameter of capillaries formed between said particulates is suitable for repealing the liquid.

47. The hydrophobic brick of claim 45, further comprising inflatable particulates size wise compatible with capillaries formed between said particulates and capable of absorbing the fluid.

48. The hydrophobic brick of claim 47, wherein said inflatable particulates, when in a deflated state, constitute less than 2 percent of the free-flowing hydrophobic aggregate by volume.

49. The hydrophobic brick of claim 47, wherein said inflatable particulates comprise a super absorbent polymer.

50. The hydrophobic brick of claim 47, wherein said inflatable particulates comprises sodium being cross linked with polyacrylic acid.

51. The hydrophobic brick of claim 47, wherein said inflatable particulates comprises anti-cracking agent.

52. The hydrophobic brick of claim 45, wherein said size distribution is selected so that the free-flowing hydrophobic aggregate is characterized by a predetermined specific weight.

53. The hydrophobic brick of claim 45, wherein said size distribution is selected so that the free-flowing hydrophobic aggregate is characterized by a minimal absorption capability.

54. The hydrophobic brick of claim 45, wherein said size distribution is selected so that the free-flowing hydrophobic aggregate is characterized by predetermined thermal properties.

55. The hydrophobic brick of claim 45, wherein said size distribution is selected so that the free-flowing hydrophobic aggregate is characterized by predetermined acoustical isolation ability.

56. The hydrophobic brick of claim 45, wherein said size distribution is selected so that the free-flowing hydrophobic aggregate is capable of allowing evaporation of liquid.

57. The hydrophobic brick of claim 43, wherein said free-flowing hydrophobic aggregate comprises a particulated core material coated by a hydrophobic powder, said hydrophobic powder comprises at least one impure element having a hydrocarbon chain attached thereto.

58. The hydrophobic brick of claim 57, wherein said hydrocarbon chain is covalently attached to said at least one impure element.

59. The hydrophobic brick of claim 58, wherein said hydrocarbon is a residue of a fatty acid.

60. The hydrophobic brick of claim 57, wherein said hydrophobic powder is bonded to said particulated core material via an adherent layer.

61. The hydrophobic brick of claim 57, wherein said hydrophobic powder comprises inflatable particulates capable of absorbing fluid when being in contact therewith.

62. The hydrophobic brick of claim 61, wherein said inflatable particulates, when in a deflated state, constitute less than 2 percent of the free-flowing hydrophobic aggregate by volume.

63. The hydrophobic brick of claim 61, wherein said inflatable particulates comprise a super absorbent polymer.

64. The hydrophobic brick of claim 61, wherein said inflatable particulates comprises sodium being cross linked with polyacrylic acid.

65. The hydrophobic brick of claim 61, wherein said inflatable particulates comprises anti-cracking agent.

66. The hydrophobic brick of claim 57, wherein said particulated core material is selected from the group consisting of sand, gravel, slag, porcelanit, dolomite, porcelain, basalt, quartz sand, coal ash, chalk, zeolite, montmorillonite, agapultite, flint, bentonite, perlite, mica, wood chips, nut shells, sawdust and combinations thereof.

67. The hydrophobic brick of claim 60, wherein said adherent layer comprises a film-forming agent.

68. The hydrophobic brick of claim 67, wherein said adherent layer further comprises a gluing agent.

69. The hydrophobic brick of claim 57, wherein said hydrophobic powder further comprises hydrophobic fumed silica.

70. The hydrophobic brick of claim 57, wherein said free-flowing hydrophobic aggregate further comprises at least one additive selected from the group consisting of a coloring agent, a UV resistant agent, a bleaching agent and an abrasive agent.

71. A method of waterproofing a portion of a structure being in contact with a ground, comprising:

providing a bed of a free-flowing hydrophobic aggregate; and  
positioning said structure over or in said bed of said free-flowing hydrophobic aggregate.

72. The method of claim 71, further comprising protecting said bed of free-flowing hydrophobic aggregate by enclosing said bed in a protective structure.

73. The method of claim 71, wherein said bed of said free-flowing hydrophobic aggregate comprises an arrangement of hydrophobic bricks, each being a protective encapsulation having a predetermined shape and encapsulating said free-flowing hydrophobic aggregate.

74. The method of claim 73, wherein said protective encapsulation is made from a degradable material.

75. The method of claim 71, wherein a thickness of said bed of free-flowing hydrophobic aggregate is between 1 and 15 cm.

76. The method of claim 71, wherein a thickness of said bed of free-flowing hydrophobic aggregate is between 4 and 10 cm.

77. The method of claim 71, further comprising mixing said free-flowing hydrophobic aggregate with lightweight aggregates.

78. The method of claim 71, wherein said free-flowing hydrophobic aggregate comprises a plurality of differently sized particulates, and further wherein at least one of a size distribution of said particulates, a contact angle between a liquid and said particulates and a characteristic distance between adjacent particulates is selected so that when the free-flowing hydrophobic aggregate is in contact with a liquid having a pressure lower than or equal to a predetermined maximal pressure, percolation of the liquid through the free-flowing hydrophobic aggregate is prevented.

79. The method of claim 78, wherein said liquid is water.

80. The method of claim 78, wherein said size distribution is selected so that a maximal diameter of capillaries formed between said particulates is suitable for repealing the liquid.

81. The method of claim 78, further comprising inflatable particulates size wise compatible with capillaries formed between said particulates and capable of absorbing the fluid.

82. The method of claim 81, wherein said inflatable particulates, when in a deflated state, constitute less than 2 percent of the free-flowing hydrophobic aggregate by volume.

83. The method of claim 81, wherein said inflatable particulates comprise a super absorbent polymer.

84. The method of claim 81, wherein said inflatable particulates comprises sodium being cross linked with polyacrylic acid.

85. The method of claim 81, wherein said inflatable particulates comprises anti-cracking agent.

86. The method of claim 78, wherein said size distribution is selected so that the free-flowing hydrophobic aggregate is characterized by a predetermined specific weight.

87. The method of claim 78, wherein said size distribution is selected so that the free-flowing hydrophobic aggregate is characterized by a minimal absorption capability.

88. The method of claim 78, wherein said size distribution is selected so that the free-flowing hydrophobic aggregate is characterized by predetermined thermal properties.

89. The method of claim 78, wherein said size distribution is selected so that the free-flowing hydrophobic aggregate is characterized by predetermined acoustical isolation ability.

90. The method of claim 78, wherein said size distribution is selected so that the free-flowing hydrophobic aggregate is capable of allowing evaporation of liquid.

91. The method of claim 71, wherein said free-flowing hydrophobic aggregate comprises a particulated core material coated by a hydrophobic powder, said hydrophobic powder comprises at least one impure element having a hydrocarbon chain attached thereto.

92. The method of claim 91, wherein said hydrocarbon chain is covalently attached to said at least one impure element.

93. The method of claim 92, wherein said hydrocarbon is a residue of a fatty acid.

94. The method of claim 91, wherein said hydrophobic powder is bonded to said particulated core material via an adherent layer.

95. The method of claim 91, wherein said hydrophobic powder comprises inflatable particulates capable of absorbing fluid when being in contact therewith.

96. The method of claim 95, wherein said inflatable particulates, when in a deflated state, constitute less than 2 percent of the free-flowing hydrophobic aggregate by volume.

97. The method of claim 95, wherein said inflatable particulates comprise a super absorbent polymer.

98. The method of claim 95, wherein said inflatable particulates comprises sodium being cross linked with polyacrylic acid.

99. The method of claim 95, wherein said inflatable particulates comprises anti-cracking agent.

100. The method of claim 91, wherein said particulated core material is selected from the group consisting of sand, gravel, slag, porcelanit, dolomite, porcelain, basalt, quartz sand, coal ash, chalk, zeolite, montmorillonite, agapultite, flint, bentonite, perlite, mica, wood chips, nut shells, sawdust and combinations thereof.

101. The method of claim 94, wherein said adherent layer comprises a film-forming agent.

102. The method of claim 101, wherein said adherent layer further comprises a gluing agent.

103. The method of claim 91, wherein said hydrophobic powder further comprises hydrophobic fumed silica.

104. The method of claim 91, wherein said free-flowing hydrophobic aggregate further comprises at least one additive selected from the group consisting of a coloring agent, a UV resistant agent, a bleaching agent and an abrasive agent.

105. A method of waterproofing an underground wall of a structure, comprising providing at least one sidewall of a free-flowing hydrophobic aggregate adjacent to the underground wall of the structure.

106. The method of claim 105, further comprising protecting said sidewall of free-flowing hydrophobic aggregate by enclosing said sidewall in a protective structure.

107. The method of claim 105, further comprising refilling said sidewall of free-flowing hydrophobic aggregate, with time.

108. The method of claim 105, wherein said sidewall of said free-flowing hydrophobic aggregate comprises an arrangement of hydrophobic bricks, each being a protective encapsulation having a predetermined shape and encapsulating said free-flowing hydrophobic aggregate.

109. The method of claim 108, wherein said protective encapsulation is made from a degradable material.

110. The method of claim 105, further comprising coating said underground wall of said structure with a waterproofing substance selected from the group consisting of a liquid and a paste.

111. The method of claim 105, wherein the structure is an existing structure, and said method is applied as a repair method.

112. The method of claim 105, wherein the structure is a new structure, and said method is applied during construction.



113. The method of claim 105, wherein said free-flowing hydrophobic aggregate comprises a plurality of differently sized particulates, and further wherein at least one of a size distribution of said particulates, a contact angle between a liquid and said particulates and a characteristic distance between adjacent particulates is selected so that when the free-flowing hydrophobic aggregate is in contact with a liquid having a pressure lower than or equal to a predetermined maximal pressure, percolation of the liquid through the free-flowing hydrophobic aggregate is prevented.

114. The method of claim 113, wherein said liquid is water.

115. The method of claim 113, wherein said size distribution is selected so that a maximal diameter of capillaries formed between said particulates is suitable for repealing the liquid.

116. The method of claim 113, further comprising inflatable particulates size wise compatible with capillaries formed between said particulates and capable of absorbing the fluid.

117. The method of claim 116, wherein said inflatable particulates, when in a deflated state, constitute less than 2 percent of the free-flowing hydrophobic aggregate by volume.

118. The method of claim 116, wherein said inflatable particulates comprise a super absorbent polymer.

119. The method of claim 116, wherein said inflatable particulates comprises sodium being cross linked with polyacrylic acid.

120. The method of claim 116, wherein said inflatable particulates comprises anti-cracking agent.

121. The method of claim 113, wherein said size distribution is selected so that the free-flowing hydrophobic aggregate is characterized by a predetermined specific weight.

122. The method of claim 113, wherein said size distribution is selected so that the free-flowing hydrophobic aggregate is characterized by a minimal absorption capability.

123. The method of claim 113, wherein said size distribution is selected so that the free-flowing hydrophobic aggregate is characterized by predetermined thermal properties.

124. The method of claim 113, wherein said size distribution is selected so that the free-flowing hydrophobic aggregate is characterized by predetermined acoustical isolation ability.

125. The method of claim 113, wherein said size distribution is selected so that the free-flowing hydrophobic aggregate is capable of allowing evaporation of liquid.

126. The method of claim 105, wherein said free-flowing hydrophobic aggregate comprises a particulated core material coated by a hydrophobic powder, said hydrophobic powder comprises at least one impure element having a hydrocarbon chain attached thereto.

127. The method of claim 126, wherein said hydrocarbon chain is covalently attached to said at least one impure element.

128. The method of claim 127, wherein said hydrocarbon is a residue of a fatty acid.

129. The method of claim 126, wherein said hydrophobic powder is bonded to said particulated core material via an adherent layer.

130. The method of claim 126, wherein said hydrophobic powder comprises inflatable particulates capable of absorbing fluid when being in contact therewith.

131. The method of claim 130, wherein said inflatable particulates, when in a deflated state, constitute less than 2 percent of the free-flowing hydrophobic aggregate by volume.

132. The method of claim 130, wherein said inflatable particulates comprise a super absorbent polymer.

133. The method of claim 130, wherein said inflatable particulates comprises sodium being cross linked with polyacrylic acid.

134. The method of claim 130, wherein said inflatable particulates comprises anti-cracking agent.

135. The method of claim 126, wherein said particulated core material is selected from the group consisting of sand, gravel, slag, porcelanit, dolomite, porcelain, basalt, quartz sand, coal ash, chalk, zeolite, montmorillonite, agapultite, flint, bentonite, perlite, mica, wood chips, nut shells, sawdust and combinations thereof.

136. The method of claim 129, wherein said adherent layer comprises a film-forming agent.

137. The method of claim 136, wherein said adherent layer further comprises a gluing agent.

138. The method of claim 126, wherein said hydrophobic powder further comprises hydrophobic fumed silica.

139. The method of claim 126, wherein said free-flowing hydrophobic aggregate further comprises at least one additive selected from the group consisting of a coloring agent, a UV resistant agent, a bleaching agent and an abrasive agent.

140. A method of waterproofing a floor of a structure, comprising providing a bed of a free-flowing hydrophobic aggregate onto said structure and positioning the floor of the structure over said bed of said free-flowing hydrophobic aggregate.

141. The method of claim 140, wherein a thickness of said bed of said free-flowing hydrophobic aggregate is between 1 and 15 cm.

142. The method of claim 140, wherein a thickness of said bed of said free-flowing hydrophobic aggregate is between 4 and 7 cm.

143. The method of claim 140, further comprising protecting said bed of said free-flowing hydrophobic aggregate by enclosing said bed in a protective structure.

144. The method of claim 140, wherein said bed of said free-flowing hydrophobic aggregate comprises an arrangement of hydrophobic bricks, each being a protective encapsulation having a predetermined shape and encapsulating said free-flowing hydrophobic aggregate.

145. The method of claim 144, wherein said protective encapsulation is made from a degradable material.

146. The method of claim 140, further comprising embedding a pipe in said bed of said free-flowing hydrophobic aggregate.

147. The method of claim 140, further comprising mixing said free-flowing hydrophobic aggregate with lightweight aggregates.

148. The method of claim 140, wherein said free-flowing hydrophobic aggregate comprises a plurality of differently sized particulates, and further wherein at least one of a size distribution of said particulates, a contact angle between a liquid and said particulates and a characteristic distance between adjacent particulates is selected so that when the free-flowing hydrophobic aggregate is in contact with a liquid having a pressure lower than or equal to a predetermined maximal pressure, percolation of the liquid through the free-flowing hydrophobic aggregate is prevented.

149. The method of claim 148, wherein said liquid is water.

150. The method of claim 148, wherein said size distribution is selected so that a maximal diameter of capillaries formed between said particulates is suitable for repealing the liquid.

151. The method of claim 148, further comprising inflatable particulates size wise compatible with capillaries formed between said particulates and capable of absorbing the fluid.

152. The method of claim 151, wherein said inflatable particulates, when in a deflated state, constitute less than 2 percent of the free-flowing hydrophobic aggregate by volume.

153. The method of claim 151, wherein said inflatable particulates comprise a super absorbent polymer.

154. The method of claim 151, wherein said inflatable particulates comprises sodium being cross linked with polyacrylic acid.

155. The method of claim 151, wherein said inflatable particulates comprises anti-cracking agent.

156. The method of claim 148, wherein said size distribution is selected so that the free-flowing hydrophobic aggregate is characterized by a predetermined specific weight.

157. The method of claim 148, wherein said size distribution is selected so that the free-flowing hydrophobic aggregate is characterized by a minimal absorption capability.

158. The method of claim 148, wherein said size distribution is selected so that the free-flowing hydrophobic aggregate is characterized by predetermined thermal properties.

159. The method of claim 148, wherein said size distribution is selected so that the free-flowing hydrophobic aggregate is characterized by predetermined acoustical isolation ability.

160. The method of claim 148, wherein said size distribution is selected so that the free-flowing hydrophobic aggregate is capable of allowing evaporation of liquid.

161. The method of claim 140, wherein said free-flowing hydrophobic aggregate comprises a particulated core material coated by a hydrophobic powder, said hydrophobic powder comprises at least one impure element having a hydrocarbon chain attached thereto.

162. The method of claim 161, wherein said hydrocarbon chain is covalently attached to said at least one impure element.

163. The method of claim 162, wherein said hydrocarbon is a residue of a fatty acid.

164. The method of claim 161, wherein said hydrophobic powder is bonded to said particulated core material via an adherent layer.

165. The method of claim 161, wherein said hydrophobic powder comprises inflatable particulates capable of absorbing fluid when being in contact therewith.

166. The method of claim 165, wherein said inflatable particulates, when in a deflated state, constitute less than 2 percent of the free-flowing hydrophobic aggregate by volume.

167. The method of claim 165, wherein said inflatable particulates comprise a super absorbent polymer.

168. The method of claim 165, wherein said inflatable particulates comprises sodium being cross linked with polyacrylic acid.

169. The method of claim 165, wherein said inflatable particulates comprises anti-cracking agent.

170. The method of claim 161, wherein said particulated core material is selected from the group consisting of sand, gravel, slag, porcelanit, dolomite, porcelain, basalt, quartz sand, coal ash, chalk, zeolite, montmorillonite, agapultite, flint, bentonite, perlite, mica, wood chips, nut shells, sawdust and combinations thereof.

171. The method of claim 164, wherein said adherent layer comprises a film-forming agent.

172. The method of claim 171, wherein said adherent layer further comprises a gluing agent.

173. The method of claim 161, wherein said hydrophobic powder further comprises hydrophobic fumed silica.

174. The method of claim 161, wherein said free-flowing hydrophobic aggregate further comprises at least one additive selected from the group consisting of a coloring agent, a UV resistant agent, a bleaching agent and an abrasive agent.

175. A method of waterproofing a roof of a structure, the roof having sidewalls, the method comprising:

applying a bed of a free-flowing hydrophobic aggregate on said roof; and  
covering said bed of said free-flowing hydrophobic aggregate, to protect said

bed.

176. The method of claim 175, wherein said covering comprises applying a floor over said bed of said free-flowing hydrophobic aggregate.

177. The method of claim 175, wherein said bed of said free-flowing hydrophobic aggregate comprises an arrangement of hydrophobic bricks, each being a protective encapsulation having a predetermined shape and encapsulating said free-flowing hydrophobic aggregate.

178. The method of claim 177, wherein said protective encapsulation is made from a degradable material.

179. The method of claim 175, wherein a thickness of said bed of said free-flowing hydrophobic aggregate is between 1 and 15 cm.

180. The method of claim 175, wherein a thickness of said bed of said free-flowing hydrophobic aggregate is between 4 and 7 cm.

181. The method of claim 175, further comprising mixing said free-flowing hydrophobic aggregate with lightweight aggregates.

182. The method of claim 175, wherein said free-flowing hydrophobic aggregate comprises a plurality of differently sized particulates, and further wherein at least one of a size distribution of said particulates, a contact angle between a liquid and



said particulates and a characteristic distance between adjacent particulates is selected so that when the free-flowing hydrophobic aggregate is in contact with a liquid having a pressure lower than or equal to a predetermined maximal pressure, percolation of the liquid through the free-flowing hydrophobic aggregate is prevented.

183. The method of claim 182, wherein said liquid is water.

184. The method of claim 182, wherein said size distribution is selected so that a maximal diameter of capillaries formed between said particulates is suitable for repealing the liquid.

185. The method of claim 182, further comprising inflatable particulates size wise compatible with capillaries formed between said particulates and capable of absorbing the fluid.

186. The method of claim 185, wherein said inflatable particulates, when in a deflated state, constitute less than 2 percent of the free-flowing hydrophobic aggregate by volume.

187. The method of claim 185, wherein said inflatable particulates comprise a super absorbent polymer.

188. The method of claim 185, wherein said inflatable particulates comprises sodium being cross linked with polyacrylic acid.

189. The method of claim 185, wherein said inflatable particulates comprises anti-cracking agent.

190. The method of claim 182, wherein said size distribution is selected so that the free-flowing hydrophobic aggregate is characterized by a predetermined specific weight.

191. The method of claim 182, wherein said size distribution is selected so that the free-flowing hydrophobic aggregate is characterized by a minimal absorption capability.

192. The method of claim 182, wherein said size distribution is selected so that the free-flowing hydrophobic aggregate is characterized by predetermined thermal properties.

193. The method of claim 182, wherein said size distribution is selected so that the free-flowing hydrophobic aggregate is characterized by predetermined acoustical isolation ability.

194. The method of claim 182, wherein said size distribution is selected so that the free-flowing hydrophobic aggregate is capable of allowing evaporation of liquid.

195. The method of claim 175, wherein said free-flowing hydrophobic aggregate comprises a particulated core material coated by a hydrophobic powder, said hydrophobic powder comprises at least one impure element having a hydrocarbon chain attached thereto.

196. The method of claim 195, wherein said hydrocarbon chain is covalently attached to said at least one impure element.

197. The method of claim 196, wherein said hydrocarbon is a residue of a fatty acid.

198. The method of claim 195, wherein said hydrophobic powder is bonded to said particulated core material via an adherent layer.

199. The method of claim 195, wherein said hydrophobic powder comprises inflatable particulates capable of absorbing fluid when being in contact therewith.

200. The method of claim 199, wherein said inflatable particulates, when in a deflated state, constitute less than 2 percent of the free-flowing hydrophobic aggregate by volume.

201. The method of claim 199, wherein said inflatable particulates comprise a super absorbent polymer.

202. The method of claim 199, wherein said inflatable particulates comprises sodium being cross linked with polyacrylic acid.

203. The method of claim 199, wherein said inflatable particulates comprises anti-cracking agent.

204. The method of claim 195, wherein said particulated core material is selected from the group consisting of sand, gravel, slag, porcelanit, dolomite, porcelain, basalt, quartz sand, coal ash, chalk, zeolite, montmorillonite, agapultite, flint, bentonite, perlite, mica, wood chips, nut shells, sawdust and combinations thereof.

205. The method of claim 198, wherein said adherent layer comprises a film-forming agent.

206. The method of claim 205, wherein said adherent layer further comprises a gluing agent.

207. The method of claim 195, wherein said hydrophobic powder further comprises hydrophobic fumed silica.

208. The method of claim 195, wherein said free-flowing hydrophobic aggregate further comprises at least one additive selected from the group consisting of a coloring agent, a UV resistant agent, a bleaching agent and an abrasive agent.

209. A method of waterproofing a reservoir, the method comprising:

placing a flooring bed of a free-flowing hydrophobic aggregate over a base of the reservoir; and

placing walls of said free-flowing hydrophobic aggregate over walls of the reservoir;

wherein at least one of said flooring bed and said walls of said free-flowing hydrophobic aggregate are covered by a protective structure designed and constructed to maintain said free-flowing hydrophobic aggregate in place.

210. The method of claim 209, wherein a thickness of said flooring bed of free-flowing hydrophobic aggregate is between 4 and 15 cm.

211. The method of claim 209, further comprising mixing said free-flowing hydrophobic aggregate with lightweight aggregates.

212. The method of claim 209, wherein said protective structure is selected from the group consisting of tiles, geotechnic fabric, concrete, plastic and combination thereof.

213. The method of claim 209, wherein at least one of said flooring bed and said sidewalls of said free-flowing hydrophobic aggregate comprises an arrangement of hydrophobic bricks, each being a protective encapsulation having a predetermined shape and encapsulating said free-flowing hydrophobic aggregate.

214. The method of claim 213, wherein said protective encapsulation is made from a degradable material.

215. The method of claim 209, wherein said free-flowing hydrophobic aggregate comprises a plurality of differently sized particulates, and further wherein at least one of a size distribution of said particulates, a contact angle between a liquid and said particulates and a characteristic distance between adjacent particulates is selected so that when the free-flowing hydrophobic aggregate is in contact with a liquid having a pressure lower than or equal to a predetermined maximal pressure, percolation of the liquid through the free-flowing hydrophobic aggregate is prevented.

216. The method of claim 215, wherein said liquid is water.

217. The method of claim 215, wherein said size distribution is selected so that a maximal diameter of capillaries formed between said particulates is suitable for repealing the liquid.

218. The method of claim 113, further comprising inflatable particulates size wise compatible with capillaries formed between said particulates and capable of absorbing the fluid.

219. The method of claim 218, wherein said inflatable particulates, when in a deflated state, constitute less than 2 percent of the free-flowing hydrophobic aggregate by volume.

220. The method of claim 218, wherein said inflatable particulates comprise a super absorbent polymer.

221. The method of claim 218, wherein said inflatable particulates comprises sodium being cross linked with polyacrylic acid.

222. The method of claim 218, wherein said inflatable particulates comprises anti-cracking agent.

223. The method of claim 211, wherein said size distribution is selected so that the free-flowing hydrophobic aggregate is characterized by a predetermined specific weight.

224. The method of claim 211, wherein said size distribution is selected so that the free-flowing hydrophobic aggregate is characterized by a minimal absorption capability.

225. The method of claim 209, wherein said free-flowing hydrophobic aggregate comprises a particulated core material coated by a hydrophobic powder, said

hydrophobic powder comprises at least one impure element having a hydrocarbon chain attached thereto.

226. The method of claim 225, wherein said hydrocarbon chain is covalently attached to said at least one impure element.

227. The method of claim 226, wherein said hydrocarbon is a residue of a fatty acid.

228. The method of claim 225, wherein said hydrophobic powder is bonded to said particulated core material via an adherent layer.

229. The method of claim 225, wherein said hydrophobic powder comprises inflatable particulates capable of absorbing fluid when being in contact therewith.

230. The method of claim 229, wherein said inflatable particulates, when in a deflated state, constitute less than 2 percent of the free-flowing hydrophobic aggregate by volume.

231. The method of claim 229, wherein said inflatable particulates comprise a super absorbent polymer.

232. The method of claim 229, wherein said inflatable particulates comprises sodium being cross linked with polyacrylic acid.

233. The method of claim 229, wherein said inflatable particulates comprises anti-cracking agent.

234. The method of claim 225, wherein said particulated core material is selected from the group consisting of sand, gravel, slag, porcelanit, dolomite, porcelain, basalt, quartz sand, coal ash, chalk, zeolite, montmorillonite, agapultite, flint, bentonite, perlite, mica, wood chips, nut shells, sawdust and combinations thereof.

235. The method of claim 228, wherein said adherent layer comprises a film-forming agent.

236. The method of claim 235, wherein said adherent layer further comprises a gluing agent.

237. The method of claim 225, wherein said hydrophobic powder further comprises hydrophobic fumed silica.

238. The method of claim 225, wherein said free-flowing hydrophobic aggregate further comprises at least one additive selected from the group consisting of a coloring agent, a UV resistant agent, a bleaching agent and an abrasive agent.

239. A method of protecting an object buried underground, the method comprising providing a free-flowing hydrophobic aggregate and surrounding the object by a layer of said free-flowing hydrophobic aggregate in a manner that said layer of said free-flowing hydrophobic aggregate is interposed between the object and the ground.

240. The method of claim 239, wherein said free-flowing hydrophobic aggregate comprises a plurality of differently sized particulates, and further wherein at least one of a size distribution of said particulates, a contact angle between a liquid and said particulates and a characteristic distance between adjacent particulates is selected so that when the free-flowing hydrophobic aggregate is in contact with a liquid having a pressure lower than or equal to a predetermined maximal pressure, percolation of the liquid through the free-flowing hydrophobic aggregate is prevented.

241. The method of claim 240, wherein said liquid is water.

242. The method of claim 240, wherein said size distribution is selected so that a maximal diameter of capillaries formed between said particulates is suitable for repealing the liquid.

243. The method of claim 240, further comprising inflatable particulates size wise compatible with capillaries formed between said particulates and capable of absorbing the fluid.

244. The method of claim 243, wherein said inflatable particulates, when in a deflated state, constitute less than 2 percent of the free-flowing hydrophobic aggregate by volume.

245. The method of claim 243, wherein said inflatable particulates comprise a super absorbent polymer.

246. The method of claim 243, wherein said inflatable particulates comprises sodium being cross linked with polyacrylic acid.

247. The method of claim 243, wherein said inflatable particulates comprises anti-cracking agent.

248. The method of claim 240, wherein said size distribution is selected so that the free-flowing hydrophobic aggregate is characterized by a predetermined specific weight.

249. The method of claim 240, wherein said size distribution is selected so that the free-flowing hydrophobic aggregate is characterized by a minimal absorption capability.

250. The method of claim 240, wherein said size distribution is selected so that the free-flowing hydrophobic aggregate is characterized by predetermined thermal properties.

251. The method of claim 240, wherein said size distribution is selected so that the free-flowing hydrophobic aggregate is characterized by predetermined acoustical isolation ability.



252. The method of claim 240, wherein said size distribution is selected so that the free-flowing hydrophobic aggregate is capable of allowing evaporation of liquid.

253. The method of claim 239, wherein said free-flowing hydrophobic aggregate comprises a particulated core material coated by a hydrophobic powder, said hydrophobic powder comprises at least one impure element having a hydrocarbon chain attached thereto.

254. The method of claim 253, wherein said hydrocarbon chain is covalently attached to said at least one impure element.

255. The method of claim 254, wherein said hydrocarbon is a residue of a fatty acid.

256. The method of claim 253, wherein said hydrophobic powder is bonded to said particulated core material via an adherent layer.

257. The method of claim 253, wherein said hydrophobic powder comprises inflatable particulates capable of absorbing fluid when being in contact therewith.

258. The method of claim 257, wherein said inflatable particulates, when in a deflated state, constitute less than 2 percent of the free-flowing hydrophobic aggregate by volume.

259. The method of claim 257, wherein said inflatable particulates comprise a super absorbent polymer.

260. The method of claim 257, wherein said inflatable particulates comprises sodium being cross linked with polyacrylic acid.

261. The method of claim 257, wherein said inflatable particulates comprises anti-cracking agent.


262. The method of claim 253, wherein said particulated core material is selected from the group consisting of sand, gravel, slag, porcelanit, dolomite, porcelain, basalt, quartz sand, coal ash, chalk, zeolite, montmorillonite, agapultite, flint, bentonite, perlite, mica, wood chips, nut shells, sawdust and combinations thereof.

263. The method of claim 256, wherein said adherent layer comprises a film-forming agent.

264. The method of claim 263, wherein said adherent layer further comprises a gluing agent.

265. The method of claim 253, wherein said hydrophobic powder further comprises hydrophobic fumed silica.

266. The method of claim 253, wherein said free-flowing hydrophobic aggregate further comprises at least one additive selected from the group consisting of a coloring agent, a UV resistant agent, a bleaching agent and an abrasive agent.



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Dr. Gal Ehrlich  
Patent Attorney  
G. E. Ehrlich (1995) Ltd.  
11 Menachem Begin Street  
52 521 Ramat-Gan

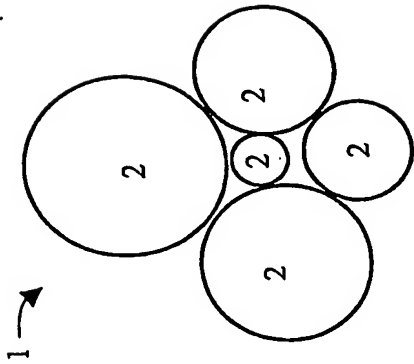


Figure 1

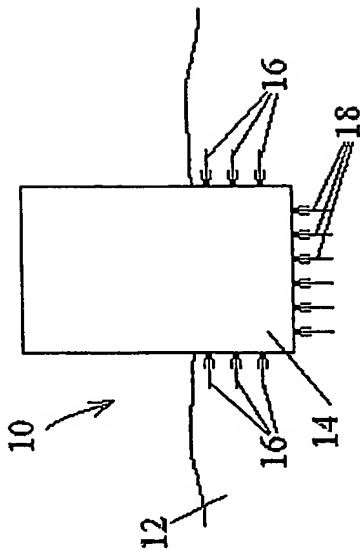


Figure 2A

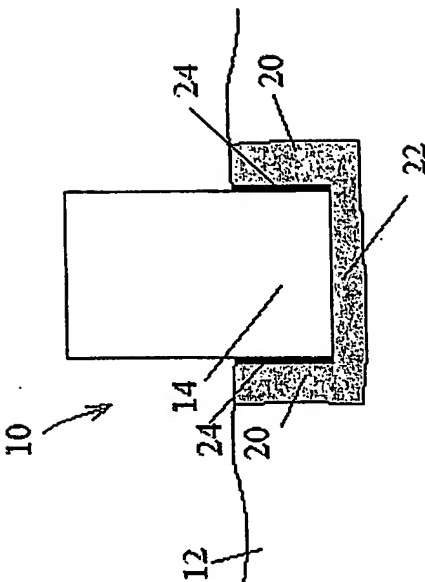
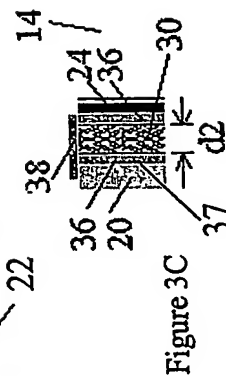
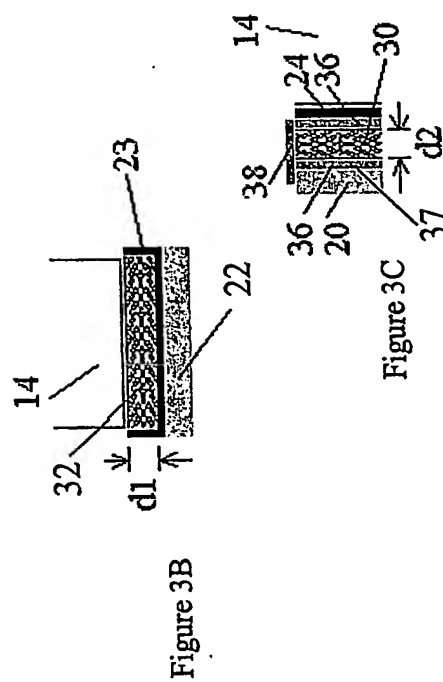
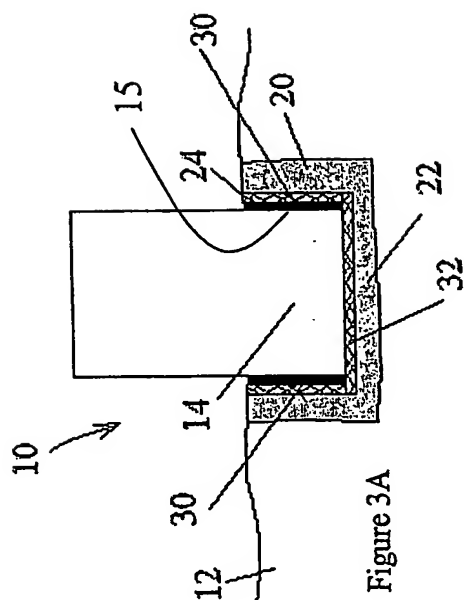


Figure 2B



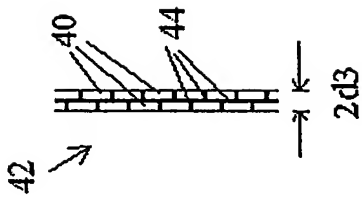


Figure 4B

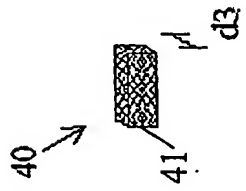


Figure 4A

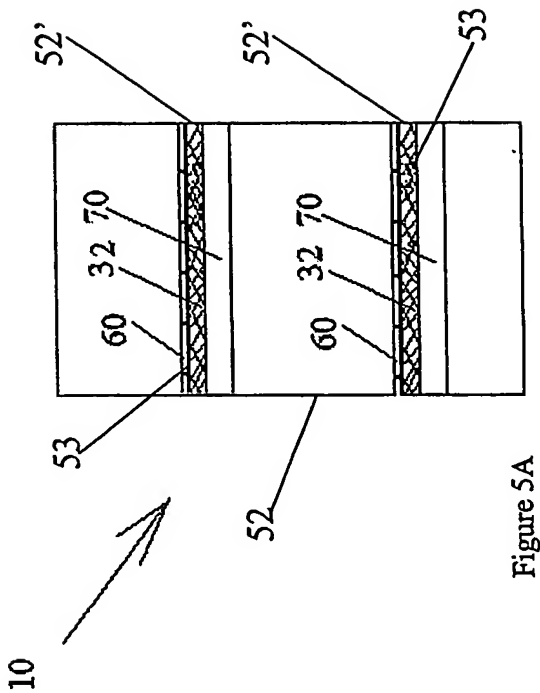


Figure 5A

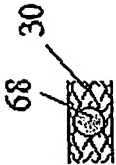


Figure 5B

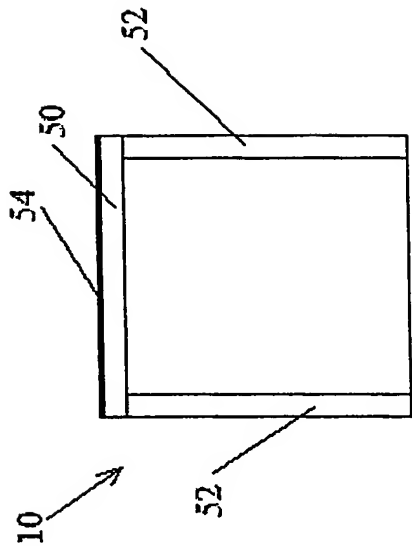


Figure 6A

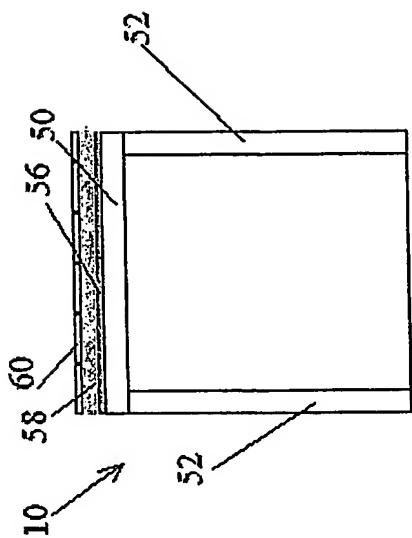
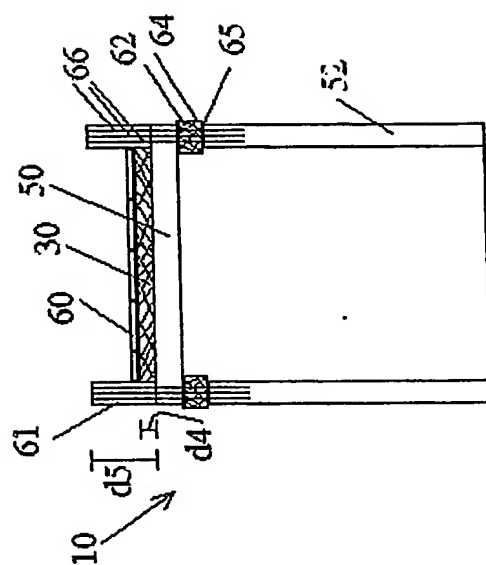


Figure 6B





**Figure 7**

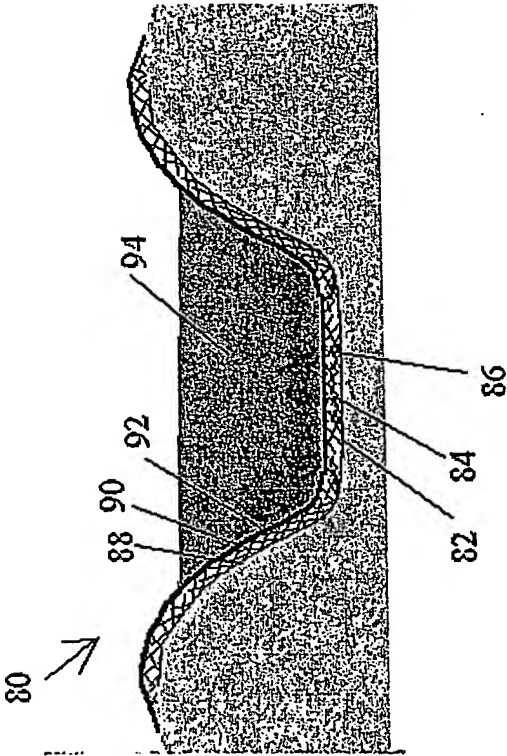


Figure 8

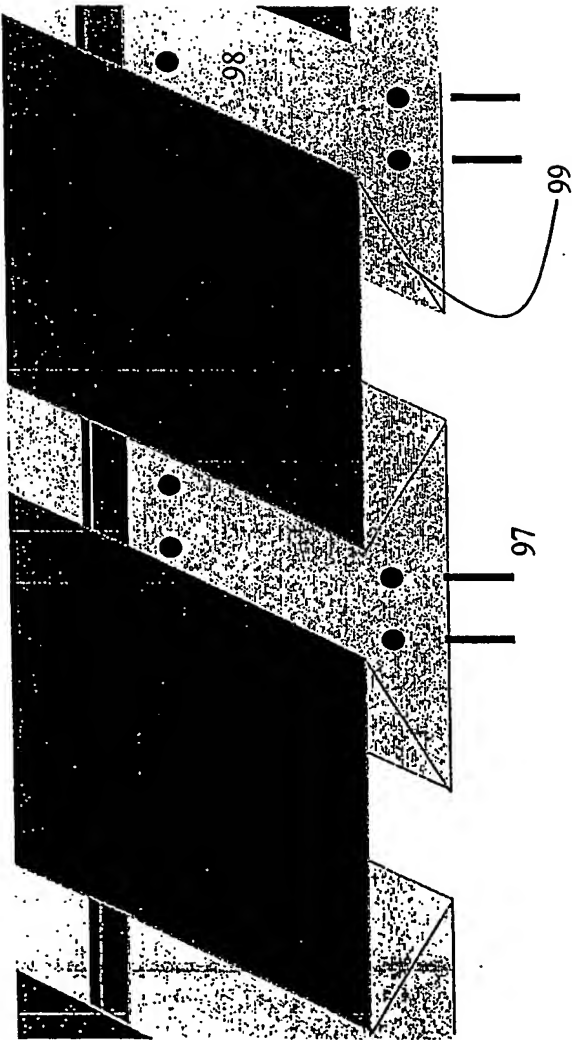


Figure 9

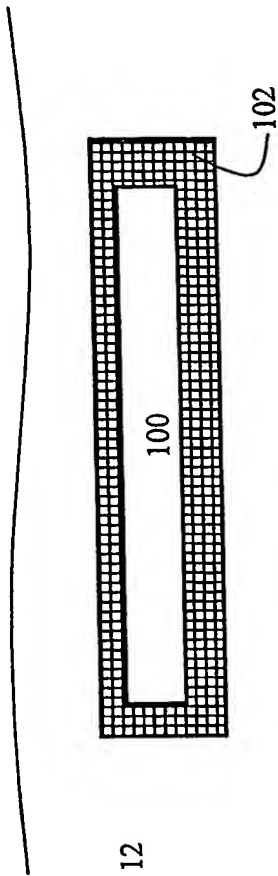


Figure 10

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